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NATIONAL DAM INSPECTION PROGRAM. FOREST LAKE DAM (NDI ID NUMBER--ETC(U)
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SUSQUEHANNA RIVER BASIN
FOREST LAKE CREEK, SUSQUEHANNA COUNTY

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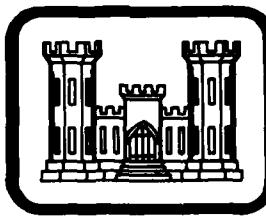
PENNSYLVANIA

FOREST LAKE DAM

NDI ID NO. PA-00968
DER ID NO. 58-21

FOREST LAKE COTTAGE OWNERS ASSOCIATION

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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Prepared by
Geo-Technical Services, Inc.
CONSULTING ENGINEERS & GEOLOGISTS
851 S. 19th Street
Harrisburg, Pennsylvania 17104

For
DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

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SUSQUEHANNA RIVER BASIN
FOREST LAKE CREEK
SUSQUEHANNA COUNTY, PENNSYLVANIA

FOREST LAKE DAM

NDI ID No. PA-00968
 DER ID No. 58-21

FOREST LAKE COTTAGE OWNERS ASSOCIATION

PHASE I INSPECTION REPORT
 NATIONAL DAM INSPECTION PROGRAM

National Dam Inspection Program. Forest Lake Dam (NDI ID Number PA-00968, DER ID Number 58-21), Susquehanna River Basin, Forest Lake Creek, Susquehanna County, Pennsylvania.
 Phase I Inspection Report

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonable possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

BRIEF ASSESSMENT OF GENERAL CONDITION

AND

RECOMMENDED ACTION

Name of Dam: Forest Lake Dam
NDI ID No. PA-00968
DER ID No. 58-21

Size: Small (12 feet high; 720 acre-feet)

Hazard Classification: Significant

Owner: Forest Lake Cottage Owners Association
Richard H. Lamon, President
R. D. #2, Box 220A
Montrose, Pennsylvania 18801

State Located: Pennsylvania

County Located: Susquehanna

Stream: Forest Lake Creek

Date of Inspection: December 10, 1980

Based on visual inspection, field survey, available records, calculations and past operation performance, Forest Lake Dam is judged to be in poor condition. The selected Spillway Design Flood (SDF) for the facility is one-half of the PMF (Probable Maximum Flood). The existing spillway will not pass the floods in excess of 10 percent of the PMF, including the 100-year flood, without overtopping the dam. Based on hydrologic and hydraulic analysis and the hazard classification, the spillway is judged to be inadequate.

The structural integrity of the dam is suspect because of the visual signs of structural deterioration, depicted by the partial failure of the downstream stone wall.

The top two-foot section of the vertical concrete headwall, in the outlet works, has a 5-degree tilt toward the reservoir. Overturning failure of this top of wall would damage the outlet works slide gate assembly and would be hazardous to the road traffic over the dam.

There is no formal inspection and maintenance program or warning system and evacuation plan in effect for Forest Lake Dam.

FOREST LAKE DAM

The following investigations and remedial measures are recommended for immediate implementation by the owner:

(1) Increase the spillway capacity to adequately pass the flood flows without overtopping the dam.

(2) Remove tree and brush from the downstream slope of the dam and near the toe of the dam, under the supervision of a professional engineer.

(3) Engage a competent professional engineer to more accurately ascertain the magnitude and nature of the seepage condition at the toe of the dam when the reservoir is at normal pool, to assess the structural stability of the dam with particular attention to the remaining stone wall at the downstream side of the embankment and the tilted upstream headwall, and to investigate erosion in the outlet channels of the service spillway and outlet works. Take corrective measures as indicated by these investigations.

In addition, it is recommended that the Owner take the following precautionary operation and maintenance measures:

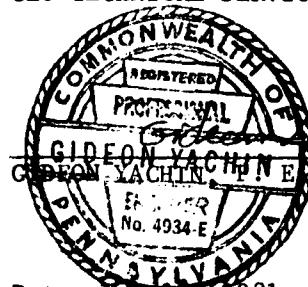
(1) Develop a detailed emergency operation procedure and warning system to facilitate timely and orderly evacuation of the downstream population due to hazardous conditions at the dam. The anticipated hazard conditions include, but are not limited to, overtopping of the dam and the development of piping conditions at the toe of the dam.

(2) When warnings of storms of major proportions are given by the National Weather Service, activate the emergency operation and warning system procedures.

(3) After satisfactory implementation of the remedial measures resulting from the recommended additional investigations, institute a formal inspection and maintenance program for the dam. As presently required by the State of Pennsylvania, the program shall include an annual inspection of the dam by a professional engineer, experienced in the design and construction of dams. Deficiencies found during annual inspections should be remedied as necessary.

Submitted by:

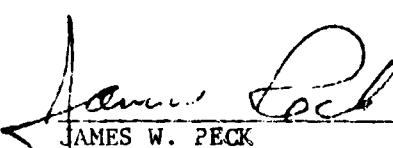
GEO-TECHNICAL SERVICES, INC.



Date: May 22, 1981

Approved:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS


JAMES W. PECK
Colonel, Corps of Engineers
Commander and District Engineer

Date: 3 JUNE 1981

FOREST LAKE DAM (PA 00888)



OVERVIEW

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
FOREST LAKE DAM
NDI# PA-00968, PENNDR # 58-21

SECTION 1

GENERAL INFORMATION

1.1 General

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Forest Lake Dam is a composite earthfill-masonry concrete structure approximately 12 feet high and 200 feet long. Most of the 200 foot length of the dam is earthen embankment. A portion of the downstream face consists of a masonry wall, a length of which has collapsed, and a portion of the upstream face consists of a concrete wall. There is no emergency spillway provided for the facility. A service spillway, consisting of two 15-inch diameter, 27-foot-long Corrugated Metal Pipes (CMP), is located at the left abutment. The outlet works, consisting of a 24-inch diameter, 40-foot-long concrete pipe, is located at the maximum section of the dam. Flow through the outlet works is regulated by a rectangular slide gate, located at the pipe inlet and accessible from the top of the concrete headwall.

b. Location. Forest Lake Dam is located on Forest Lake Creek in Forest Lake Township, Susquehanna County, Pennsylvania. The Borough of Montrose, Pennsylvania, is situated about 5 miles southeasterly of the dam at the intersection of State Routes 29 and 706. The dam and reservoir are contained within the Laurel Lake, Pennsylvania and New York 7.5 minute series USGS Quadrangle Map, at Latitude N 41°52'48" and Longitude W 75°57'38". A Location Map is shown on Exhibit E-1.

c. Size Classification. Small (12 feet high, 720 acre-feet storage capacity at top of dam).

d. Hazard Classification. Significant (see paragraphs 3.1e and 5.1c).

e. Ownership. Forest Lake Cottage Owners Association; Richard H. Lamon, President. R. D. #2, Box 220A, Montrose, Pennsylvania 18801.

f. Purpose of Dam. The original purpose of the impounded water was for ice harvesting and recreation. Additionally, water releases from the impoundment activated a saw mill (see Booth Mill Pond, Exhibit E-1). Presently, the lake is being used for recreation.

g. Design and Construction History. Information related to the design and construction of the dam is not available. Data obtained from the Pennsylvania Department of Environmental Resources (PennDER) indicate that the dam was constructed in 1842. Although "as-built" drawings are not available, inspection reports, correspondence and photographs document operation and maintenance activities since 1919. The present service spillway was added after the June 1972 flood.

h. Normal Operational Procedure. The pool is maintained at the level of the service spillway (invert of two 15-inch diameter CMP). Lake level has been drawn down by approximately three feet every winter since 1965 to protect boat docks from ice damage.

1.3 Pertinent Data.

a. <u>Drainage Area.</u> (square miles)	0.84
b. <u>Discharge at Damsite.</u> (CFS)	
Maximum known flood at damsite since construction	Not Known
Outlet works at maximum pool elevation	50
Spillway capacity at maximum pool elevation	
Design Conditions	Not Known
Existing Conditions	14
c. <u>Elevation.</u> (feet above msl)*	
Top of Dam	
Design Conditions	Not Known
Existing Conditions (at lowest point)	1528.8
Maximum Pool	
Design Conditions	Not Known
Existing Conditions (at low point of dam)	1528.8
Normal Pool (spillway crest)	1526.4
Upstream Invert Outlet Works	Not Known
Downstream Invert Outlet Works	1518.5
Streambed at Toe of Dam	1516.8
Maximum Tailwater (at max. spillway discharge), approximately	1517
d. <u>Reservoir Length.</u> (feet)	
Normal Pool	3050
Maximum Pool (at lowest dam crest elevation)	3200

*For survey datum, see Par. 3.1a

e.	<u>Storage.</u> (acre-feet)		
	Normal Pool (including pre-construction Lake storage)	604	
	Maximum Pool		
	Design Conditions	Not Known	
	Existing Conditions	720	
f.	<u>Reservoir Surface.</u> (acres)	46	
	Normal Pool		
	Maximum Pool		
	Design Conditions	Not Known	
	Existing Conditions	51	
g.	<u>Dam.</u>		
	Type - Composite earthfill-masonry structure		
	Length (feet) (including spillway)	200	
	Height (feet)	12	
	Top Width (feet)		
	Design Conditions	Not Known	
	Existing Conditions	14' to 30'	
	Side Slopes - Vary, see typical sections (Exhibits A-3 and A-4).		
	Zoning - See type, above.		
	Cut-Off	Not Known	
	Impervious Core	Not Known	
	Grout Curtain	Not Known	
h.	<u>Diversion and Regulating Tunnel</u>	None	
i.	<u>Spillway</u> (service spillway, no emergency spillway)		
	Type - Two 15-inch diameter CMP		
	Length (feet)	27'	
	Crest Elevation (Invert of 15" dia. pipes)	1526.4	
	Upstream Channel	None	
	Downstream Channel - Road drainage ditch, See Exhibit A-1.		
j.	<u>Outlet Works</u>		
	Type - 24-inch diameter concrete pipe.		
	Length (feet)	40	
	Closure and Regulating Facilities - Reported 3' x 2' rectangular slide gate at the pipe inlet. For location of stem, see Exhibit A-4.		
	Access - From top of dam at concrete headwall.		

SECTION 2
ENGINEERING DATA

2.1 Design.

a. Data Available. There is no available information related to the design and construction of the dam. The earliest information available consists of data compiled by the Water Supply Commission of Pennsylvania in 1919. Inspection reports accompanied with photographs indicate the conditions of the dam in 1935, 1951 and 1965. The above cited information and related correspondence is available on file with PENNADER.

b. Design Features. The dam and appurtenances are described in Paragraph 1.2a. The original extent of the near-vertical, downstream dry stone wall is not known. Available data indicates that the dam was subject to frequent overtopping prior to the construction of the service spillway.

2.2 Construction Records.

There are no records available for evaluation of construction methods and the classification or quality of materials placed in the dam. Information given by Delbert W. Potts, Caretaker for the Cottage Owners Association, indicates that an unregulated upper intake existed prior to the construction of the present service spillway. This upper intake was located above the inlet to the outlet works at the face of the concrete headwall. Overflow through a 12-inch CMP inlet was conveyed by a vertical elbow into the 24-inch diameter outlet pipe within the earthfill portion of the dam. The upper intake was replaced with the present service spillway in 1972.

2.3 Operation.

Prior to 1965, the outlet works were in continuous operation during periods of low flow supplying water to a saw mill (see Booth Mill Pond, Exhibit E-1). The present normal operation of the facility is described in paragraph 1.2h, Section 1.

2.4 Other Investigations.

In addition to on-site inspections cited in paragraph 2.1a, investigations were conducted in response to complaints by the Cottage Owners Association regarding drawdown of the Lake by the saw mill operator. These investigations resulted in repairs of the slide gate and the installation of the 12-inch CMP overflow, prior to 1968.

2.5 Evaluation.

a. Availability of Data. Engineering data was extracted from PENNADER files. The owner stated that he has no plans of the dam. Pertinent dam features were obtained by survey on the inspection date (12/10/1980). There are no other sources of information available for the evaluation of the facility.

b. Adequacy. In the absence of plans, engineering specifications and construction records, assessment of the structural integrity of the dam and its safety must be based on the combination of available cited data, visual inspection, performance history, as well as the hydrologic and hydraulic analysis presented in Section 5.

c. Validity. There is no reason to question the validity of the available data.

SECTION 3
VISUAL INSPECTION

3.1 Observations.

a. General. The overall appearance of the dam is poor. Location of observed deficiencies are shown on the General Plan, presented in Exhibit A-1, Appendix A. The profile and typical sections of the dam are presented in Exhibits A-2, A-3 and A-4 and are based on field survey made on the day of inspection. The survey datum for this inspection is elevation 1527 feet above mean sea level which is stamped on the USGS Bench Mark (No. TT15K, 1931) on the large sandstone slab, upstream of the service spillway. On the inspection date (12/10/1980), the lake was being drawn down for the winter. The lake level was approximately at elevation 1523.6, or 2.8 feet below its normal level. Deficiencies observed during the field inspection are described below and further illustrated in Exhibit A-1, Appendix A. Visible features are depicted in photographs, presented in Appendix C.

b. Dam. Observations made during inspection indicate that the dam is in poor condition. The upstream slope varies, having a vertical concrete wall along a distance of 19 feet in the vicinity of the outlet works (see Outlet Works, Exhibit A-4). The remaining upstream face is unprotected earthfill embankment with the steepest slope being 1V to 1.43H (see Exhibits A-3, A-4 and photographs 1 and 2, Appendix C). The top width of the dam varies from 14-feet at the left abutment to 30 feet at the outlet works. The lowest top of dam elevation is 1528.8 and is located near the right abutment (see top of dam profile, Exhibit A-2). Lake Hill Road (TR 643) traverses the crest of the dam, rising in elevation at each abutment (see Exhibits A-1 and A-2). The downstream face of the dam includes a 20-foot long, near-vertical dry masonry wall, rising from the downstream toe of the dam near the left abutment, to an approximate elevation 1526 (see Section A, Exhibit A-3 and Photographs 3 and 4, Appendix C). The top left end of the stone wall is characterized by overhanging stones, up to 12-inches off the vertical face and is subjected to a surcharge from the upstream earthfill section. The balance of the stone wall had collapsed (see Photographs 3 and 5, Appendix C) within the limits shown in Exhibit A-1. Between the outlet works and the right abutment, the downstream face of the dam is an earth embankment, varying in slope from 1V:1.34H at the outlet works (see Exhibit A-4) to 1V:1.5H at the right abutment. Approximately 3 Gallons Per Minute (GPM) seepage was observed to emanate from the toe of the dam between the collapsed stone wall and the outlet works. There was no evidence of piping at the toe of the dam on the day of the inspection. Growth of trees within the dam proper is limited to a 24-inch diameter ash on the downstream slope, near the right abutment, and two 16-inch diameter trees near the toe at the left abutment (see Exhibit A-1 and Photographs 3 and 4, Appendix C).

c. Appurtenant Structures. The service spillway is located on the left abutment. It consists of two 15-inch diameter Corrugated Metal Pipe (CMP) culverts under Lake Hill Road (TR-643). The inlet is in good condition with the pipes being flush with a vertical stone headwall (see Photographs 5 and 6, Appendix C). An extended side road ditch conveys the flow from the termination of the pipes to the downstream channel of Forest Lake Creek. Portions of the service spillway outlet channel, immediately below the downstream face of the dam, are severely eroded (see Exhibit A-1 and photographs 3 and 4, Appendix C).

The outlet works is located near the maximum section of the dam, approximately 80 feet east of the right abutment. On the day of the inspection, the water surface in the reservoir was above the intake and its condition could not be verified. Available data indicates the existence of a trash rack at the inlet to the 24-inch diameter concrete pipe. The slide gate is operable by means of a stem, located near the middle of the concrete headwall (see Exhibits A-1 and A-4).

The top of wall elevation at the right end of the upstream headwall is 0.2 foot higher than that at the left end and the entire top 2-foot section is tilted upstream by approximately 5 degrees off vertical. The visible portion of this wall has a 4V to 1H batter on the back side. On the day of the inspection, the reservoir was being lowered for the winter and the flow through the 24-inch diameter concrete pipe was approximately 200 GPM, creating a free overfall into the outlet channel. The outlet of the concrete pipe appears to be in good condition. The outlet channel extends to the left of the outlet pipe, joining the natural stream channel approximately 15 feet downstream of the pipe outlet. Immediately downstream of the outlet pipe, the bottom of the channel is eroded to a depth of 18 to 24 inches (see Exhibits A-1, A-4 and Photograph 4, Appendix C).

d. Reservoir Area. The northwestern part of the watershed is predominantly farm land with an average slope of 10 percent. The balance of the watershed is predominantly wooded, having an average slope of 12 percent on the left bank of Forest Lake. The right bank of the lake is steeply sloped, ranging from 25 percent at the widest part of the lake to 8 percent at the right abutment of the dam. The watershed rises from the normal lake level elevation 1526.4 to the maximum elevation 1940 feet above mean sea level, at the northeastern portion of the drainage divide (see Exhibit E-1). Extensive development is limited to the lake shoreline, consisting of permanent and seasonal residences. Sediment deposit at the lake inlet is not pronounced. Geologic conditions are described in Appendix F.

e. Downstream Channel. Immediately downstream of the Forest Lake Dam, the bottom width of the channel varies between 6 to 10 feet and both stream banks are steep and partially wooded. The top of the right bank is 6 feet above streambed and the overbank slope is approximately 10 percent. The top of the left bank is 14 feet above the streambed. The downstream channel characteristics are illustrated in Photograph 9, Appendix C. The average slope of the channel along the first 2200-foot stretch of the stream below the dam is 0.033 foot per foot (3.3%). A 4-foot diameter culvert is located 1900 feet below the dam, with the

top of the road being 4.5 feet above the streambed. A low-lying two story dwelling is located on the left bank of the stream, approximately 100 feet upstream of the culvert. The first floor elevation of the dwelling is 4.6 feet above the streambed. A trailer is located on the right bank of the creek downstream of the culvert, approximately 2100 feet below the dam and 15 feet above the streambed. Stream channel characteristics, both upstream and downstream of the culvert, and the location of the dwellings with reference to the stream are shown in Photographs 10 and 11, Appendix C. A house is located 150 feet from the right bank of the stream, approximately 4000 feet downstream of the dam. The basement floor elevation of this house is 1.8 feet above the streambed. Approximately 7100 feet downstream of the dam, a house is located 50 feet from the right bank of the stream whose first floor elevation is 12 feet above the streambed. The location of the cited dwellings are shown in Exhibit E-1. Observed downstream hazard conditions indicate that a few lives could be lost and significant property damage incurred should Forest Lake Dam fail. Consequently, the hazard classification for this facility is considered to be significant.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedure.

From mid April to October of each year, the reservoir is maintained at the service spillway invert elevation 1526.4 with excess inflow discharging through the spillway into Forest Lake Creek. In the early part of October, the reservoir is drawn down for the winter by approximately 3 feet to facilitate repairs and maintenance of boat dock facilities and to prevent ice damage to the docks. The reservoir level is raised beginning in early April of each year to elevation 1526.4. Reservoir elevations are regulated by a slide gate at the inlet to the 24-inch diameter concrete pipe.

4.2 Maintenance of Dam.

The dam is visited daily by the owner's caretaker, who lives and works on a farm near the dam site. The owner does not make formal inspections of the dam, nor does he provide a regular maintenance schedule for the dam. The road on top of the dam is maintained by the Township.

4.3 Maintenance of Operating Facilities.

The outlet works is the only operating facility at the dam. The operating wheel for the slide gate is kept at the caretaker's residence. Maintenance of the slide gate is limited to seasonal operation of the lift mechanism.

4.4 Warning System.

There is no emergency operation and warning system in effect at the present time.

4.5 Evaluation.

The appearance of the dam indicates that periodic inspections are necessary to check the conditions at the downstream toe of the dam. Maintaining the downstream slope of the dam and the immediate area below the downstream toe clear of brush will facilitate such inspections. Periodic inspections should include, as a minimum, the measurement of toe seepage with reference to the water level in the reservoir and the severity of erosion conditions in the outlet channels of the service spillway and the outlet works. The annual drawdown of the reservoir level facilitates the inspection and maintenance of the upstream face of the dam. These inspections and the resulting maintenance activities should include, as a minimum, periodic measurements of the tilted concrete headwall at the outlet works and the removal of brush and debris from the service spillway inlet.

An emergency operation and warning system is necessary to prevent loss of life resulting from a dam failure.

SECTION 5
HYDROLOGY AND HYDRAULICS

5.1 Evaluation of Features.

a. Design Data. There is no information available to indicate the design criteria for the Forest Lake Dam.

b. Experience Data. There are no records available to indicate the maximum pool attained by the reservoir during past floods. The June 1972 flood resulting from Hurricane Agnes is believed to be the flood of record. The owner's representative stated that a temporary emergency spillway was excavated on the left abutment in June 1972 and that the dam was not overtopped during that flood. This trench was subsequently replaced by the present service spillway. The caretaker reported that the dam was not overtopped during the 1972 flood and that no overtopping has occurred since the installation of the service spillway. Available data (1931 correspondence, PENNDEA Files) indicates that overtopping of the dam was a frequent occurrence for a period of at least 50 years.

c. Visual Observations. Based on visual inspection, described in Section 3 of this report, and field survey, the observations relevant to hydrology and hydraulics are described as follows:

(1) Dam: The top of dam has an irregular profile and its lowest point is at elevation 1528.8 (see Exhibit A-2, Appendix A). The normal pool level during the spring and summer months is at elevation 1526.4. Consequently, the maximum rise in the reservoir pool level prior to overtopping the dam is 2.4 feet. Since the dam was constructed at the outlet of a natural lake, the effective storage behind the dam is the storage capacity above the upstream invert of the outlet works.

(2) Appurtenant Structures: The spillway is located at the left abutment of the dam, consisting of two 15-inch diameter Corrugated Metal Pipes (see Exhibits A-2 and A-3, Appendix A; and Photographs 5, 6, 7 and 8, Appendix C). Computed spillway capacity used in this report is 14 cubic feet per second (cfs), provided that the spillway inlet is unobstructed by debris (see sheet D-7, Appendix D).

The slide gate at the inlet to the 24-inch diameter outlet works is normally closed when the reservoir pool level is at elevation 1526.4. The maximum discharge capacity of the outlet works at normal pool level is approximately 50 cfs (see Sheets D-7 and D-8, Appendix D).

(3) Reservoir Area: There are no upstream structures of significant influence on the rate and time of flood inflow into Forest Lake. There are no visible indications to suggest drastic change in the prevailing

watershed land use to significantly alter the rate of inflow into the reservoir during extreme floods.

(4) Downstream Conditions: The spillway and dam crest overtopping discharge capacities are not affected by tailwater conditions for the entire range of discharges considered in this study (see Sheets D-9 and D-10, Appendix D). Failure of the dam would result in flooding of one dwelling, located on the left bank of Forest Lake Creek and approximately 1800 feet downstream of the dam. Basement flooding will also occur in a home, located on the right bank of the creek and approximately 4000 feet downstream of the dam, should the dam fail. The observed downstream conditions indicate that a significant hazard classification is warranted for Forest Lake Dam.

d. Method of Analysis. Hydrologic and hydraulic evaluation was made in accordance with the procedures and guidelines established by the U.S. Army, Corps of Engineers, Baltimore District, Phase - I Safety Inspection of Dams. The analysis has been performed utilizing the HEC-1DB program developed by the U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California. A brief description of program capabilities, as well as the input and output data used specifically for this analysis, is presented in appendix D.

e. Summary of Analysis.

(1) Spillway Design Flood: According to the criteria established by the Office of the Chief of Engineers (OCE) for the size (Small) and hazard potential (Significant) of Forest Lake Dam, the Spillway Design Flood (SDF) is between 100-year Flood and the one-half Probable Maximum Flood (1/2 PMF). Based on the potential hazard downstream of the dam and the relatively large storage in the reservoir the 1/2 PMF is selected as the SDF for the Forest Lake Dam.

(2) Results of Analysis: Pertinent results are tabulated in appendix D. Forest Lake Dam was evaluated for the normal reservoir pool level at elevation 1526.4, which is the prevailing condition between April and October of each year. Since the slide gate is in closed position during the aforementioned period, flow through the outlet works was excluded from the evaluation of spillway adequacy. The derived peak inflow and outflow from the reservoir for the selected SDF of 1/2 PMF are 1230 cfs and 1100 cfs, respectively. Since the spillway capacity is 14 cfs, all floods in excess of the 0.1 PMF will overtop the dam (see Summary of Dam Safety Analysis, Sheet D-16, Appendix D). The computed peak discharge for the 100-year flood is 700 cfs. Therefore, the spillway capacity is 2% of the 100-year flood.

(3) Spillway Adequacy: Since the spillway is not capable of passing the one-half of the PMF without overtopping the dam, it is considered to be inadequate.

SECTION 6
STRUCTURAL STABILITY

6.1 Visual Observations.

The visual inspection of Forest Lake Dam is described in Section 3. Observations that are relevant to structural stability of the dam and the appurtenant structures are evaluated below:

a. Dam. The collapsed portion of the downstream dry masonry wall is located left of the outlet works (see Exhibit A-1). Whereas, the lowest elevation of the dam crest is located immediately to the right of the outlet works (see Exhibit A-2). Therefore, the collapse of the stone wall, within the visible limits shown in Exhibit A-1, is not attributed to the reported past overtopping occurrences of the dam (see Paragraph 5.1b, Section 5). The surcharge loads on the wall from the upstream earthfill and road traffic (see Section A, Exhibit A-3) are the possible causes of the stone wall failure. On the basis of visual inspection and the available data, the structural integrity of the dam section adjacent to the collapsed stone wall, cannot readily be verified.

The observed seepage at the toe of the dam on December 10, 1980 was approximately at the rate of 3 GPM with no evidence of piping. The reservoir was being drawn down for the winter and the water surface in the reservoir was 2.8 feet below the normal pool elevation. Therefore, the observed rate of seepage does not reflect the prevailing conditions at the toe when the reservoir is at normal pool elevation.

b. Appurtenant Structures. Observed erosion in the service spillway channel is located approximately 20 feet downstream of the stone wall face of the dam. The present depth of the eroded channel bottom is approximately 18 inches and the slope of the channel is 18 percent. Extensive erosion in the bottom of the earth channel can cause instability of the channel banks. Should the right bank of the channel collapse due to extensive erosion of the channel bottom, the collapse could affect the stability of the dam.

The outlet works concrete headwall retains the adjacent upstream earthfill section of the dam. The top two foot section of this wall is tilted toward the reservoir. The observed 5 degree tilt from the vertical is above a horizontal construction joint, extending along the entire length of the wall. Information relative to wall reinforcement is inadequate to assess the stability of the tilted portion of the wall against overturning. Failure of the tilted wall section would bend the stem and cause damage to the slide gate. Additionally, failure of this wall will be hazardous to the roadway traffic over the dam.

6.2 Design and Construction Data.

Available design and construction data are inadequate to assess the structural integrity of the dam.

6.3 Past Performance.

The available data indicate that the partial collapse of the downstream dry stone wall occurred prior to 1965. There is no other information available related to structural failure of the dam or the appurtenant structures.

6.4 Post Construction Changes.

The present service spillway on the left abutment was constructed in June 1972. This spillway replaced a 12-inch diameter overflow pipe that was located above the outlet works intake.

6.5 Seismic Stability.

The dam is located in Seismic Zone No. 1 and may be subject to minor earthquake induced dynamic forces. Normally, it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake loading. However, since the static stability of the composite section of Forest Lake Dam is questionable, its seismic stability cannot be assessed.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS FOR REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety.

(1) Based on the visual inspection, field survey, available records, calculations and past operational performance, the Forest Lake Dam is judged to be in poor condition. The size classification of the facility is Small and its hazard classification is Significant. In accordance with the recommended guidelines, the selected Spillway Design Flood (SDF) for the facility is the one-half of the PMF (Probable Maximum Flood). Results of the hydrologic and hydraulic analysis indicate that for the selected SDF, the peak outflow from the reservoir is approximately 1100 cubic feet per second (cfs). The spillway capacity is the equivalent of the peak outflow resulting from a flood magnitude of 0.1 PMF. Therefore, all floods in excess of 0.1 PMF will cause overtopping of the Forest Lake Dam. Although the dam has withstood frequent overtoppings since its construction, the magnitude of the maximum past overtopping could not be verified. Based on the hydrologic and hydraulic analysis and the hazard classification, the spillway is judged to be inadequate. The spillway will not pass the 100-year frequency flood without overtopping the dam.

(2) The structural integrity of the dam is suspect because of the visual signs of structural deterioration, depicted by the partial failure of the downstream stone wall. Due to insufficient design and construction information, an assessment of the structural stability cannot be made.

(3) The top two-foot section of the vertical concrete headwall, in the outlet works, has a 5-degree tilt toward the reservoir. Overturning failure of this top of wall would damage the outlet works slide gate assembly and would be hazardous to the roadway traffic over the dam. Information relative to wall reinforcement is inadequate to assess the stability of the tilted portion of the wall against overturning.

(4) A summary of the observed deficiencies is described below:

<u>Description</u>	<u>Observed Deficiencies</u>
<u>Dam</u>	12-inch overhang and partial failure of the downstream stone wall; irregular top of dam elevation; seepage at toe of dam between the collapsed stone wall and the outlet works; trees at toe and downstream slope.
<u>Service Spillway</u>	Eroded bottom of spillway outlet channel, downstream of the dam.

<u>Description</u>	<u>Observed Deficiencies</u>
<u>Outlet Works</u>	Top of vertical concrete headwall is tilted toward the reservoir by 5 degrees; 18" to 24" erosion in the bottom of the outlet channel.

(5) There is no formal inspection and maintenance program in effect for Forest Lake Dam.

b. Adequacy of Information. The data collected from previously cited inspection reports, past performance, visual inspection and computations performed as part of this study are sufficient for the Phase I dam safety assessment, delineated in sub-paragraph a. of this section.

c. Urgency. The recommendations in Paragraph 7.2 should be implemented as soon as practical or as dictated by the recommended additional investigations, that follow.

d. Necessity for Further Investigations. In order to accomplish some of the remedial measures outline in Paragraph 7.2, further investigations by a professional engineer experienced in the design and construction of dams will be necessary.

7.2 Recommendations and Remedial Measures.

a. The following investigations and remedial measures are recommended for immediate implementation by the Owner:

(1) Increase the spillway capacity to adequately pass flood flows without overtopping the dam.

(2) Remove tree and brush from the downstream slope of the dam and the trees near the toe of the dam, under the supervision of a professional engineer.

(3) Engage a competent professional engineer to more accurately ascertain the magnitude and nature of the seepage condition at the toe of the dam when the reservoir is at normal pool, to assess the structural stability of the dam with particular attention to the remaining stone wall at the downstream side of the embankment and the tilted upstream headwall, and to investigate erosion in the outlet channels of the service spillway outlet works. Take corrective measures as indicated by these investigations.

b. In addition, it is recommended that the owner take the following precautionary operation and maintenance measures:

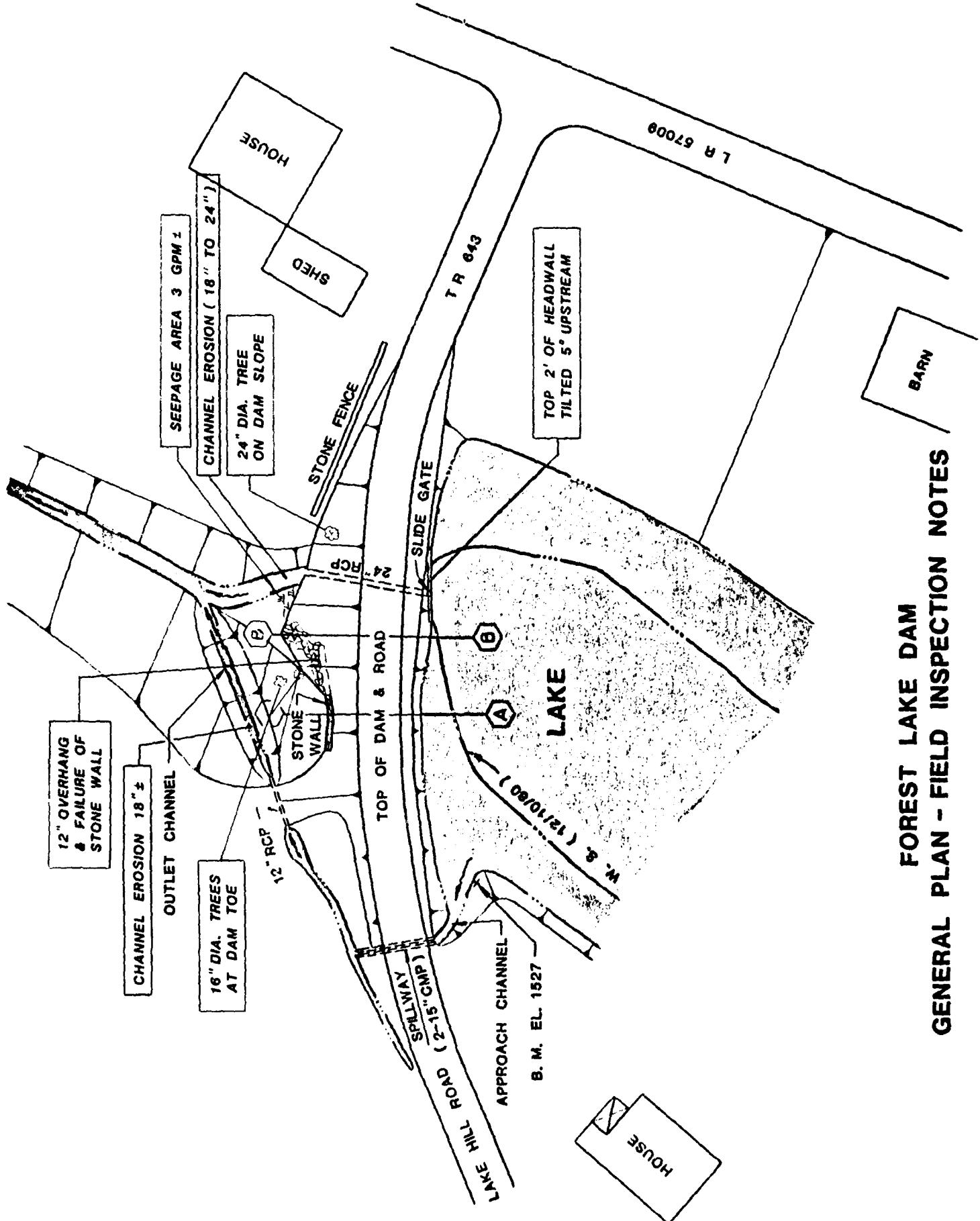
(1) Develop a detailed emergency operation procedure and warning system to facilitate timely and orderly evacuation of the downstream population due to hazardous conditions at the dam. The anticipated hazard conditions include, but are not limited to, overtopping of the dam and the development of piping conditions at the toe of the dam.

(2) When warnings of a storm of major proportions are given by the National Weather Service, activate the emergency operation and warning system procedures.

(3) After satisfactory implementation of the remedial measures resulting from the recommended additional investigations, institute a formal inspection and maintenance program for the dam. As presently required by the State of Pennsylvania, the program shall include an annual inspection of the dam by a professional engineer, experienced in the design and construction of dams. Deficiencies found during annual inspections should be remedied as necessary.

APPENDIX A

VISUAL INSPECTION - CHECKLIST AND FIELD SKETCHES



FOREST LAKE DAM
GENERAL PLAN - FIELD INSPECTION NOTES

JOB FOREST LAKE DER 58-21

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

SHFT LINE

DATE DRAWN RJM

DATE 1-8-81

CHECKED BY

DATE

SCALE HORZ. 1" = 50' VERT. 1" = 4'

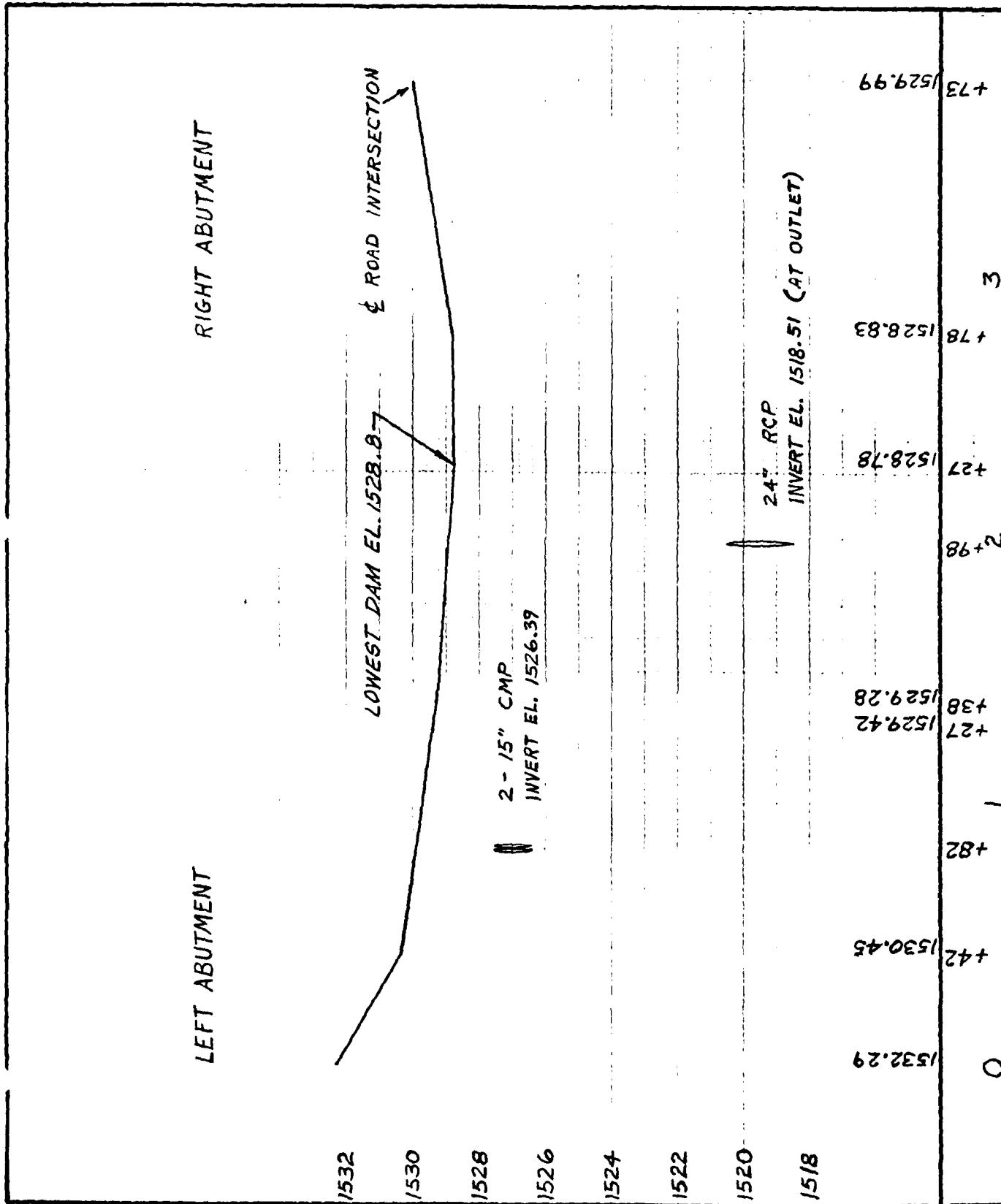
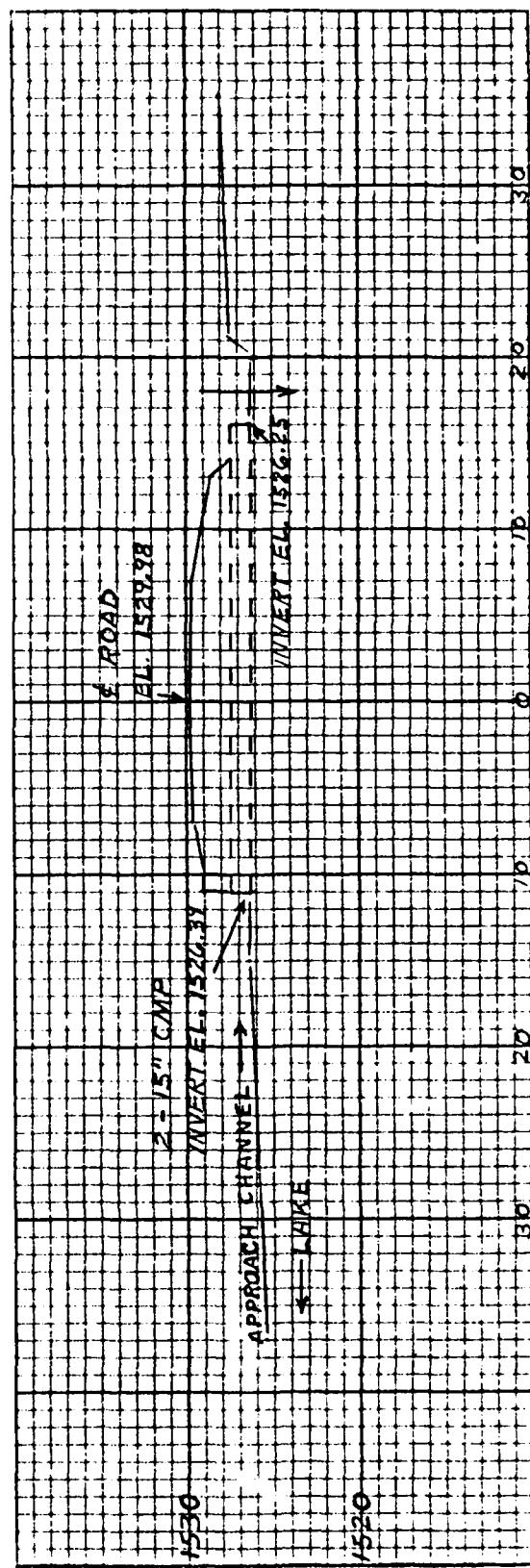
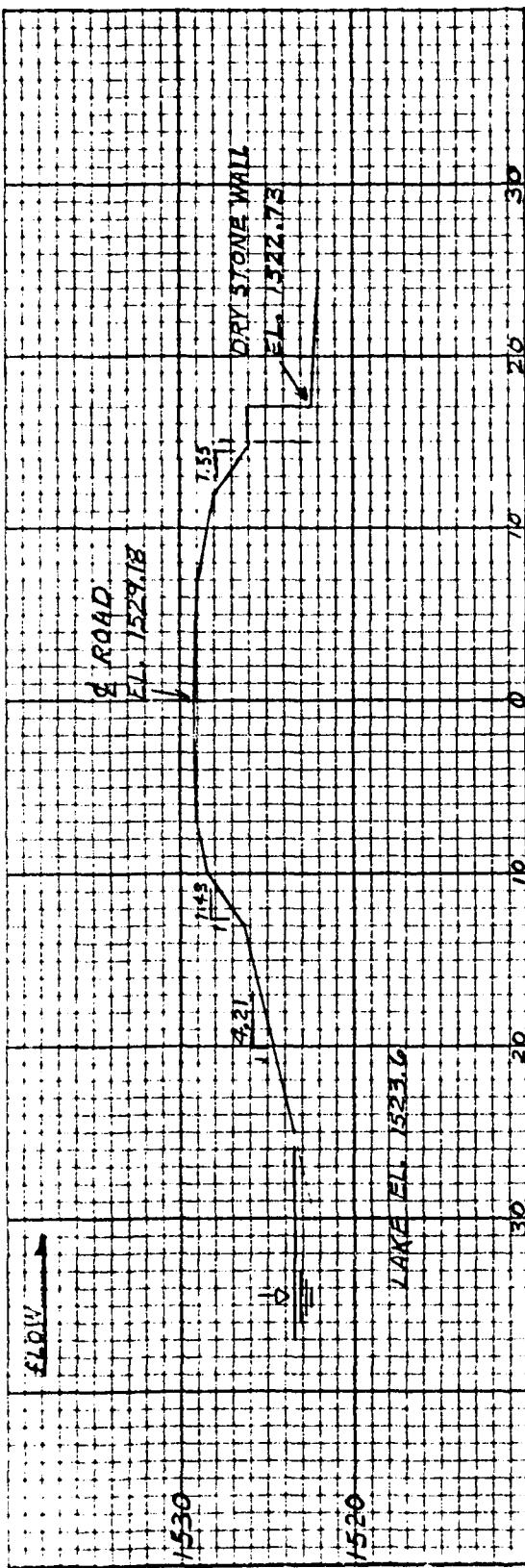
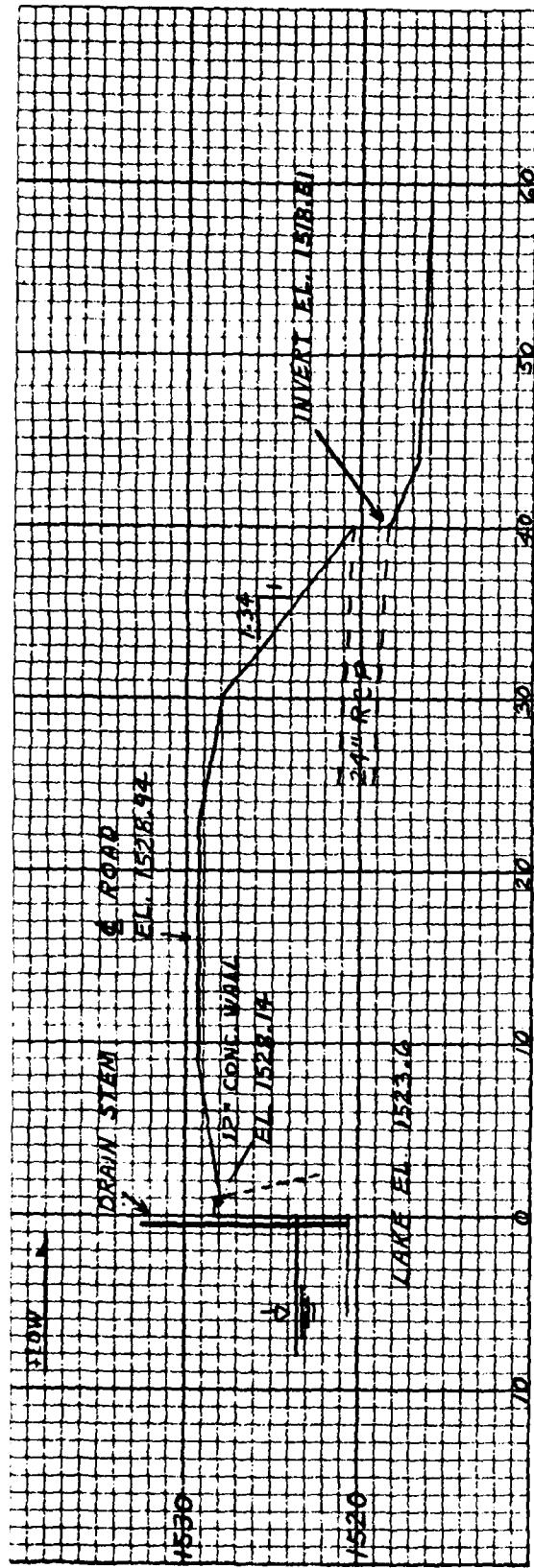


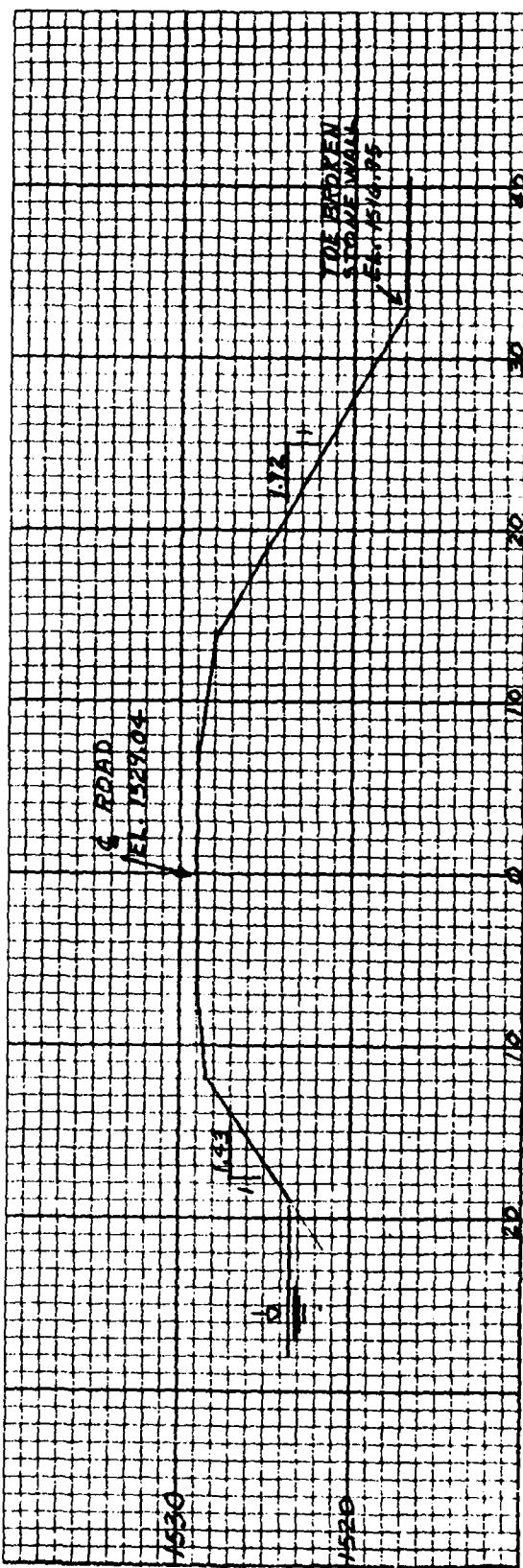
EXHIBIT A-2



TYPICAL DAM SECTIONS



OUTLET WORKS



SECTION B

TYPICAL DAM SECTIONS

**CHECK LIST
VISUAL INSPECTION
PHASE 1**

RECORDED BY James Diaz

EMBANKMENT

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA • 00968
SURFACE CRACKS	None	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None	
SLoughing OR Erosion OF EMBANKMENT AND ABUTMENT SLOPES	None on embankment. Service spillway outlet channel on left abutment below 12" RCP has channel erosion 18" - deep (see Exhibit A-1 and photograph 3, Appendix C).	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	For vertical alignment, see Exhibit A-2. Curved horizontal alignment near each abutment (see Exhibit A-1).	
RIPRAP FAILURES	There is no riprap on the upstream face of the dam. Dry stone wall on left downstream side has 12" + overhang with wall failure to right of overhang resulting in many fallen stones (see Exhibit A-1 and photograph 4, Appendix C).	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Good (no emergency spillway).	

EMBANKMENT

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA -
DAMP AREAS IRREGULAR VEGETATION (LUSH OR DEAD PLANTS)	Isolated toe seepage area, left of outlet works (see Exhibit A-1).	00968
ANY NOTICEABLE SEEPAGE	Flow of 3 GPM ⁺ at downstream toe, left of outlet pipe. Negligible accumulation of fines.	
STAFF GAGE AND RECORDER	None	
DRAINS	None other than outlet works.	
ROCK OUTCROPS	None in vicinity of dam. The large horizontal sandstone slab (15' dia. x 2' thick) on the left abutment near the spillway approach appears to be a large boulder (see photograph 5, Appendix C).	
	16" diameter tree on left abutment toe of dam and 24" diameter tree on right abutment toe of dam (see Exhibit A-1). No evidence of leakage along the roots of these trees.	

OUTLET WORKS

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDIM PA -	00968
INTAKE STRUCTURE	None		
OUTLET CONDUIT (CRACKING AND SPALLING OF CON- CRETE SURFACES)	24-inch diameter Concrete Pipe with upstream control.		
OUTLET STRUCTURE	None. The downstream end of the outlet is a 24" RCP.		
OUTLET CHANNEL	An eroded ditch 18 to 24" deep extends left from the outlet pipe to the center of the natural stream channel (see Exhibit A-1).		
GATE(S) AND OPERA- TIONAL EQUIPMENT	2' by 3 $\frac{1}{2}$ wide rectangular gate (reported) is attached to the upstream con-crete endwall. This gate is operated twice a year to lower the lake in winter and raise it to "recreation" pool for the summer.		
CONCRETE SURFACES, CRACKS, SPALLING, JOINTS	The concrete headwall on the upstream face of the dam is sound. However, the top 2-foot section of this wall is tilted upstream about 5 degrees off vertical. Downstream face of this wall has a 4 to 1 slope (4V:1H).		

EMERGENCY SPILLWAY

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDMPA - 968
TYPE AND CONDITION	No constructed emergency spillway. High flood flows will overtop dam.	
APPROACH CHANNEL	NA	
SPILLWAY CHANNEL AND SIDEWALLS	NA	
STILLING BASIN PLUNGE POOL	NA	
DISCHARGE CHANNEL	NA	
BRIDGE AND PIERS EMERGENCY GATES	NA	

SERVICE SPILLWAY

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA -	00968
TYPE AND CONDITION	Two 15" CMP installed under road in left abutment. During "Agnes" storm in 1972, a 5' wide channel was excavated across the road in this area to prevent overtopping of the dam.		
APPROACH CHANNEL	Excavated earth channel on left abutment.		
OUTLET STRUCTURE	Two 15" CMP under road on left abutment, terminating at roadway ditch across road.		
DISCHARGE CHANNEL	Excavated and eroded earth ditch on left abutment.		

INSTRUMENTATION

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDI# PA.	00968
MONUMENTATION SURVEYS	USGS Bench mark on large sandstone slab on left abutment near spillway approach channel (elevation 1527);		
OBSERVATION WELLS	None		
WEIRS	None		
PIEZOMETERS	None		
OTHERS	None		
OPERATION & MAINTENANCE DATA	Slide gate is opened in early October every year to lower lake by approximately 3-feet and closed in early April to return pool to recreation level.		

RESERVOIR AREA AND DOWNSTREAM CHANNEL

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS	NDIN PA: 00968
SLOPES: RESERVOIR	Gentle wooded and farmland slopes	
SEDIMENTATION	Slight	
DOWNSTREAM CHANNEL (OBSTRUCTIONS, DEBRIS, ETC.)	Natural wooded stream channel	
SLOPES, CHANNEL VALLEY	Natural steep wooded slopes	
APPROXIMATE NUMBER OF HOMES AND POPULATION	Four occupied dwellings	
WATERSHED DESCRIPTION	Wooded mountain area with a few open farmland areas. Farmland predominant within the northwestern part of the watershed.	PAUL B ORN

APPENDIX B

ENGINEERING DATA - CHECKLIST

CHECK LIST
ENGINEERING DATA
PHASE I

NAME OF DAM	FOREST LAKE DAM	ITEM	REMARKS	NDIN PA - 00968
PERSONS INTERVIEWED	Delbert W. Potts, Caretaker of Grounds			
REGIONAL VICINITY MAP	See Exhibit E-1, Appendix E			
CONSTRUCTION HISTORY	Construction and design documents are not available. Available information indicates that the dam was constructed in 1842.			
AVAILABLE DRAWINGS	None			
TYPICAL DAM SECTIONS	For typical sections obtained by survey (12/10/80), see Appendix A.			
OUTLETS	24-inch diameter concrete pipe with upstream control			
PLAN DETAILS	Not available			
DISCHARGE RATINGS	Not available			

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS	NDIMPA - 00968
SPILLWAY PLAN SECTION DETAILS	Two 15-inch diameter CMP on left abutment. No emergency spillway. Design drawings not available. For present conditions, see Appendix A.	
OPERATING EQUIP. MENT PLANS AND DETAILS	Slide gate on upstream end of 24-inch diameter outlet works. Lift mechanism consists of a wheel operated stem, located at mid-point of the outlet works headwall. Wheel is being kept at a nearby farm.	
DESIGN REPORTS	None available	
GEOLOGY REPORTS	None available	
DESIGN COMPUTATIONS: HYDROLOGY AND HYDRAULICS STABILITY ANALYSES SEEPAGE ANALYSES	None available	
MATERIAL INVESTIGATIONS: BORING RECORDS LABORATORY TESTING FIELD TESTING	None available	PACT 711

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS	NDINPA - 00968
BORROW SOURCES	Not known	
POST CONSTRUCTION DAM SURVEYS	None available prior to 1980. For conditions on 12/10/80, see top of dam profile and typical sections, Appendix A.	
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Inspection reports (1935, 1951, and 1965) on file with PENNDEER.	
HIGH POOL RECORDS	No formal records are available	
MONITORING SYSTEMS	None	
MODIFICATIONS	Installation of service spillway consisting of two 15-inch diameter CMP on the left abutment. These CMP are reported to have replaced 12-inch CMP overflow that existed above the outlet works.	

**CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)**

ITEM	REMARKS	NDINPA - 00968
PRIOR ACCIDENTS OR FAILURES	Not reported	
MAINTENANCE RECORDS MANUAL	Not available	
OPERATION RECORDS MANUAL	Not available	
OPERATIONAL PROCEDURES	April to October of each year, the normal pool is at the invert elevation of the Service Spillway pipes. The reservoir level is lowered by at least three feet every winter to protect and maintain boat docks.	
WARNING SYSTEM AND/OR COMMUNICATION FACILITIES	Not available	
MISCELLANEOUS		

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

NDI ID # 00968
PENNDER ID # 58-021

SIZE OF DRAINAGE AREA: 0.84 square miles

ELEVATION TOP NORMAL POOL 1526.4 STORAGE CAPACITY 604 acre-feet

ELEVATION TOP FLOOD CONTROL POOL NA STORAGE CAPACITY NA

ELEVATION MAXIMUM DESIGN POOL Unknown STORAGE CAPACITY Unknown

ELEVATION TOP DAM: 1528.8 STORAGE CAPACITY: 720 acre-feet

SPILLWAY DATA

CREST ELEVATION: 1526.4 feet msl

TYPE: Two 15-inch diameter Corrugated Metal Pipes

CREST LENGTH: NA

CHANNEL LENGTH: (Outlet channel) 140 feet to stream

SPILOVER LOCATION: Left abutment

NUMBER AND TYPE OF GATES: None

OUTLET WORKS

TYPE: 24-inch diameter Concrete Pipe

LOCATION: Maximum dam section; 80-feet east of right abutment

ENTRANCE INVERTS: Not known

EXIT INVERTS: Elevation 1518.5 feet msl

EMERGENCY DRAWDOWN FACILITIES. Operable slide gate

HYDROMETEOROLOGICAL GAGES

TYPE: None

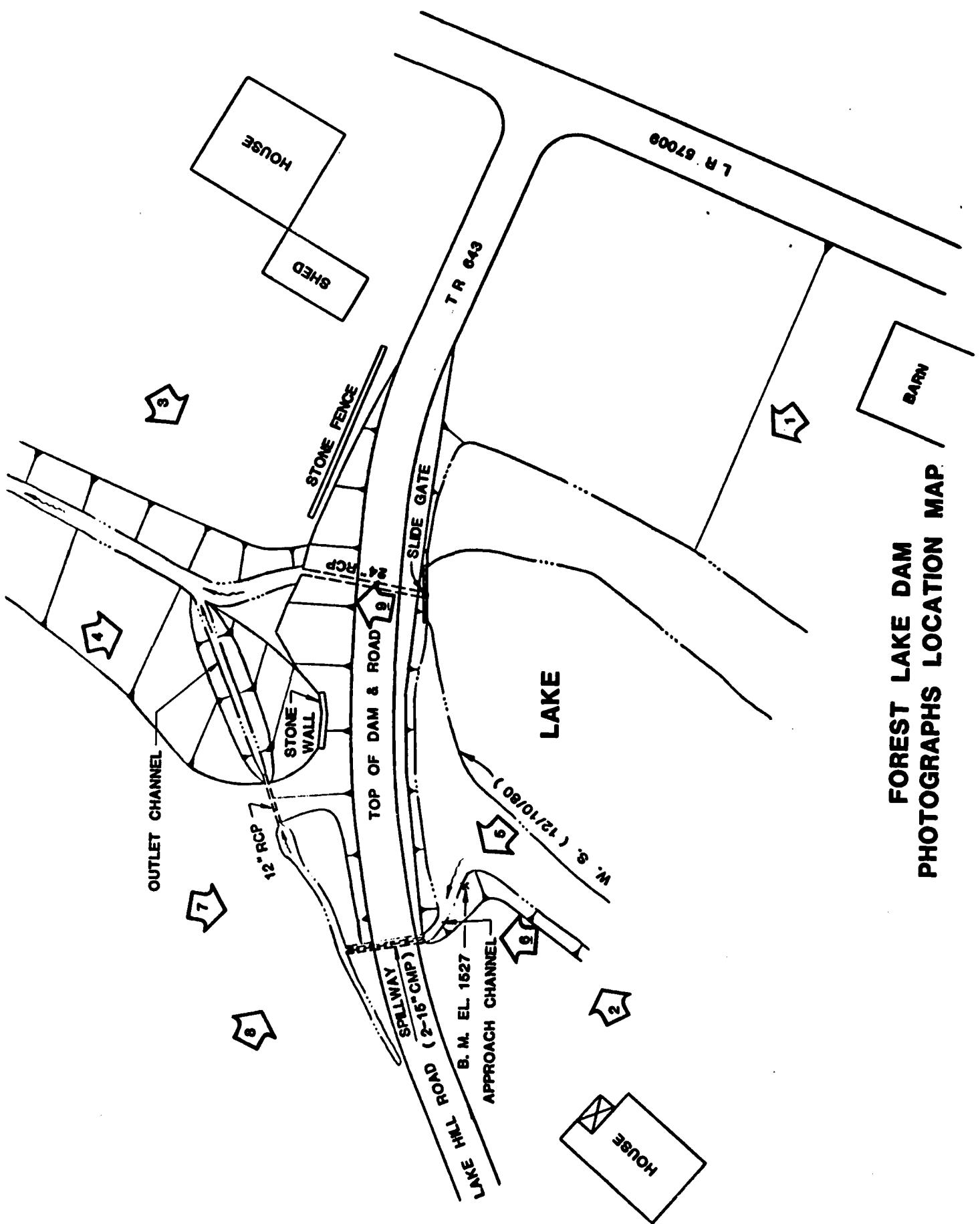
LOCATION: NA

RECORDS: None

MAXIMUM NON-DAMAGING DISCHARGE: 14 cfs

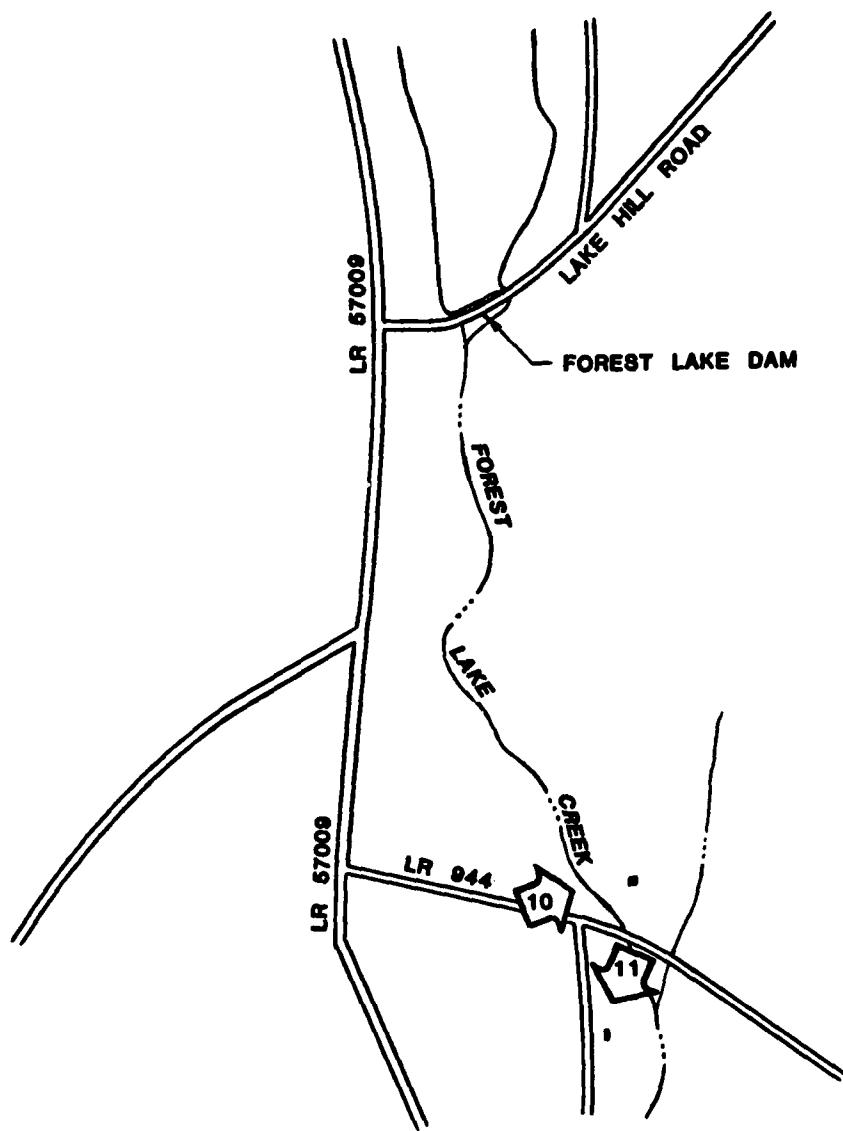
APPENDIX C

PHOTOGRAPHS



FOREST LAKE DAM PHOTOGRAPHS LOCATION MAP

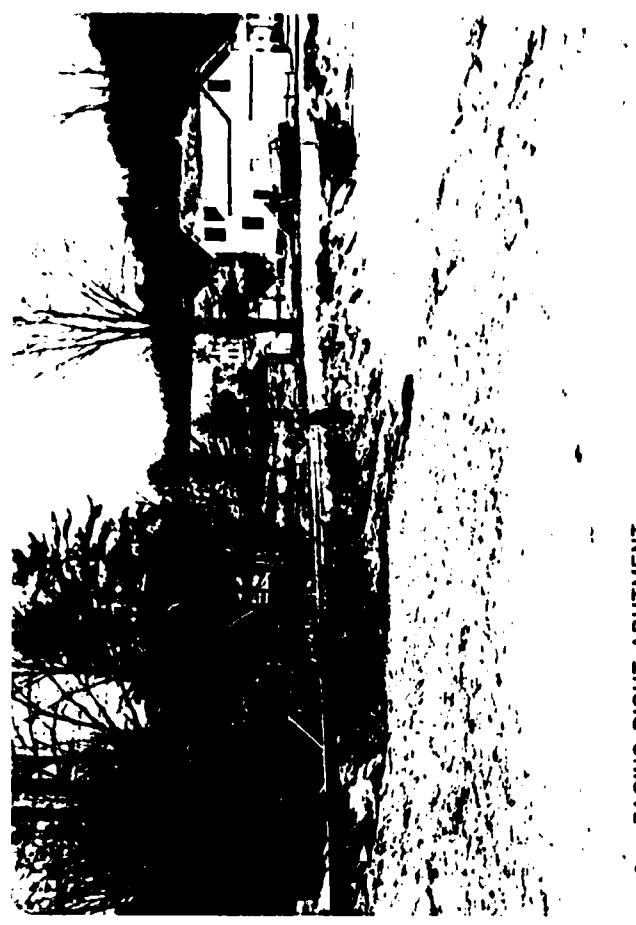
EXHIBIT C-1



**FOREST LAKE DAM
DOWNSTREAM PHOTOGRAPHS LOCATION MAP**



1. FACING LEFT ABUTMENT



2. FACING RIGHT ABUTMENT

1 & 2 UPSTREAM FACE OF DAM



3 & 4 DOWNSTREAM OF DAM

3. VIEW FROM RIGHT BANK

4. VIEW FROM LEFT BANK, SHOWING STONE WALL, FALL, ETC.



5. APPROACH CHANNEL (USGS B.M ON ROCK AT LEFT)



6. INLET TO PIPE SPILLWAY (BEHIND MAN)



7. LOOKING UPSTREAM ON RIGHT ABUTMENT



8. SPILLWAY OUTLET CHANNEL

SPILLWAY (TWO, 16" DIAMETER CMP)

DOWNSTREAM HAZARD

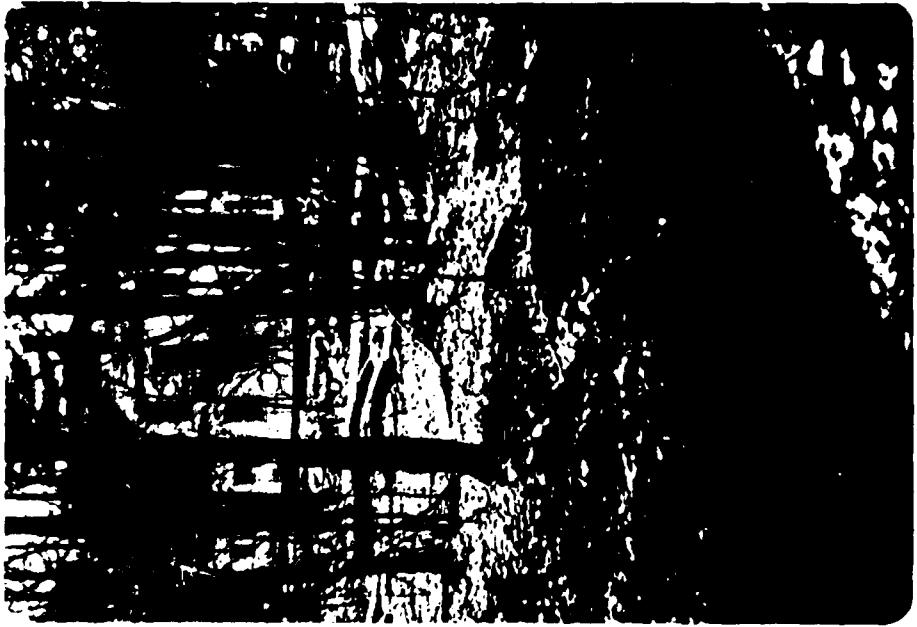
11. TRAILER (2100' DOWNSTREAM), ON RIGHT BANK



11. TRAILER (2100' DOWNSTREAM), ON RIGHT BANK



9. DOWNSTREAM AT TOE OF DAM



10. HOUSE (1800' DOWNSTREAM)
N. SIDE OF ROAD, EAST OF CREEK

APPENDIX D

HYDROLOGY AND HYDRAULICS

SUMMARY DESCRIPTION
OF
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY INVESTIGATIONS

The hydrologic and hydraulic evaluation for this inspection report has employed computer techniques using the Corps of Engineers computer program identified as the Flood Hydrograph Package (HEC-1) Dam Safety Version.

The program has been designed to enable the user to perform two basic types of hydrologic analyses: (1) the evaluation of the over-topping potential of the dam, and (2) estimate the downstream hydrologic-hydraulic consequences resulting from assumed structural failures of the dam. A brief summary of the computation procedures typically used in the dam over-topping analysis is shown below.

- Development of an inflow hydrograph to the reservoir.
- Routing of the inflow hydrograph(s) through the reservoir to determine if the event(s) analyzed would over-top the dam.
- Routing of the outflow hydrograph(s) of the reservoir to desired downstream locations. The results provide the peak discharge, time of the peak discharge and maximum stage of each routed hydrograph at the outlet of the reach.

The output data provided by this program permits the comparison of downstream conditions just prior to a breach failure with that after a breach failure and the determination as to whether or not there is a significant increase in the hazard to loss of life as a result of such a failure.

The results of the studies conducted for this report are presented in Section 5.

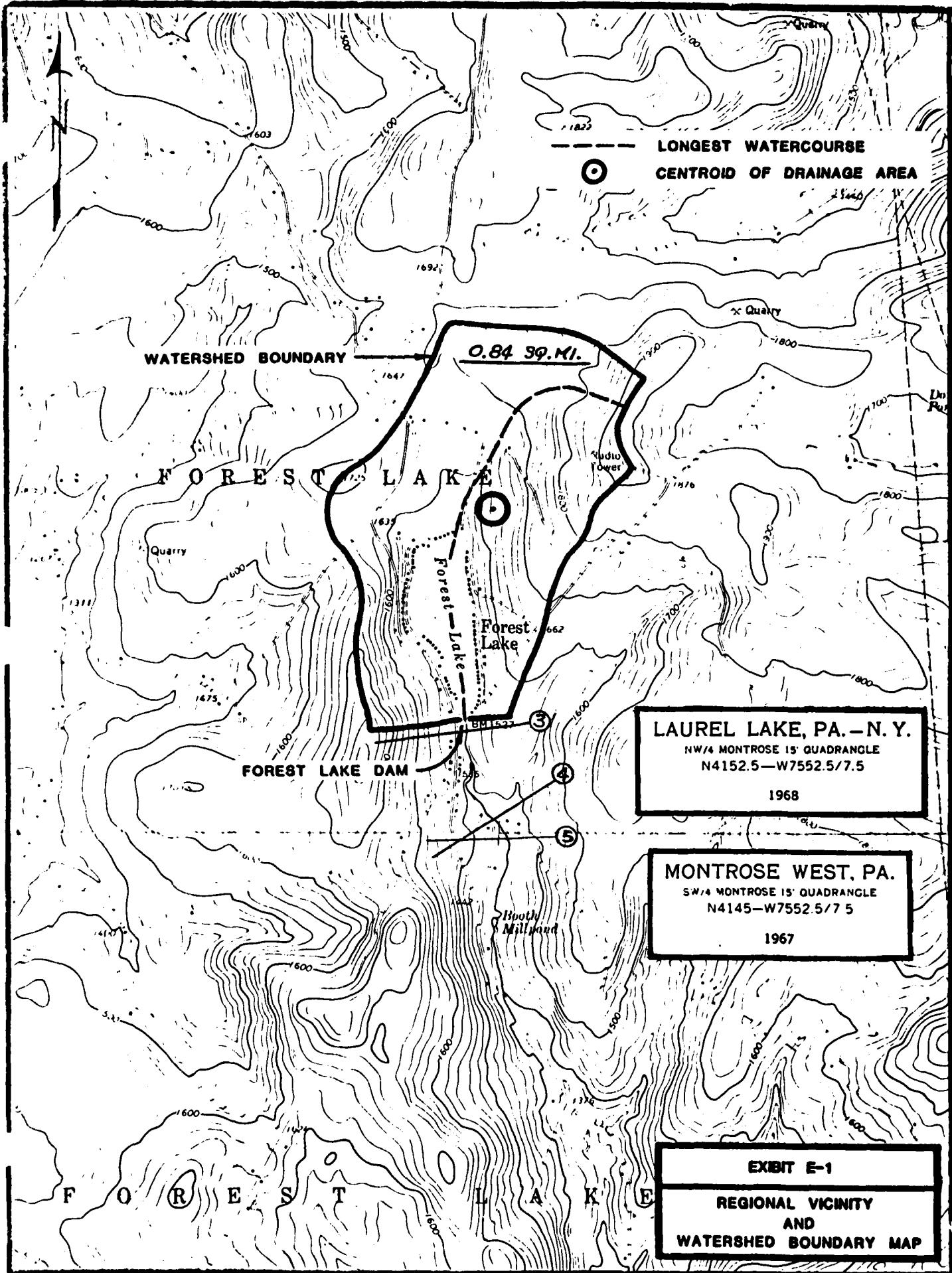
For detailed information regarding this program, refer to the Users Manual for the Flood Hydrograph Package (HEC-1), Dam Safety Investigations prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB **FOREST LAKE DAM PA-0968**
SHEET NO. _____ OF _____
CALCULATED BY **WEH** DATE _____
CHECKED BY _____ DATE _____
SCALE _____

SUMMARY OF HYDRAULIC CALCULATIONS

- 1.) PERFORM A MULTI-RATIO OVERTOPPING ANALYSIS
2. DUE TO THE DOWNSTREAM HAZARD CLASSIFICATION,
No BREACH ANALYSIS WILL BE MADE.



GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOH FOREST LAKE DAM PA-0968

SHET NO 1 OF
CALCULATED BY WEH DATE 2/9/81
CHECKED BY DATE
SCALE

GENERAL DATA

RIVER BASIN	SUSQUEHANNA (SUB-BASIN 4)*
STREAM NAME	FOREST LAKE CREEK
JAM NAME	FOREST LAKE DAM
NID ID No.	PA-00968
DER ID No.	58-021
OWNER	FOREST LAKE COTTAGE ASSOC.
LOCATION	FOREST LAKE TWP, SUSQUEHANNA CO., PA.
	LAT. N 41°52'48"
	LONG. W 75°57'38"
SIZE CATEGORY	SMALL
HAZARD CATEGORY	SIGNIFICANT
UPSTREAM DAMS	NONE
DOWNSTREAM DAMS	NONE

* PENN-DER WATER RESOURCES BULLETIN No.5

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB FOREST LAKE DAM PA - 0968

SHET NO

OF

CALCULATED BY IWEH

DATE 2/11/61

CHECKED BY

DATE

SCALE

DRAINAGE BASIN & UNIT HYDROGRAPH DATA

DRAINAGE AREA	0.84 Sq. Mi.
LENGTH OF RESERVOIR - NORMAL	3050 FT.
- MAX.	3200 FT.

SNYDER UNIT HYDROGRAPH COEFFICIENTS

AS SUPPLIED BY BALT. DIST. COE (SUSQUEHANNA BASIN ZONE II)

$$C_P = 0.62$$

$$C_L = 1.50$$

$$\text{LAG TIME } = T_P = C_L (L \times L_{ca})^{0.3}$$

$L = 1.41$ mi. RESERVOIR OUTLET TO DRAINAGE DIVIDE

$L_{ca} = 0.70$ mi. RESERVOIR OUTLET TO CENTROID

$$\therefore T_P = 1.50 (1.41 \times 0.70)^{0.3} = 1.49 \text{ HRS}$$

RAINFALL DATA

PER HYDROMETEKOLOGICAL REPORT No. 40 (SUSQUEHANNA BASIN)

GEOGRAPHIC ADJUSTMENT FACTOR = 0.945

PMF RAINFALL = 22.2" (24 HR. & 200 Sq. Mi.)

$$22.2 \times 0.945 = 21.0$$

RAINFALL DISTRIBUTION

6 HR	118%
12 HR	127%
24 HR	136%
48 HR	142%

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB FOREST LAKE DAM PA - 0968

SHLF NO.

CALCULATED BY WEH

DATE 2/11/81

CHECKED BY

DATE

SCALE

DAM DATA

TOP OF DAM ELEV. (LOW POINT)	1528.8
DAM LENGTH (INC. SPILLWAY)	200'
DAM HEIGHT	12'
DAM WIDTH	14' (ROAD)
"C" VALUE - DAM (PER HYDRAULICS OF BRIDGE WATERWAYS)	3.0
NON LEVEL DAM	

LENGTH OF DAM	BELOW ELEV.
0'	1528.8
105'	1529
305'	1530
365'	1531
410'	1532

SPILLWAY DATA

THERE IS NO CONVENTIONAL EMERGENCY SPILLWAY

THE SERVICE SPILLWAY CONSISTS OF 2 - 15"φ CMPs
WHICH MAINTAIN THE LAKE SURFACE @ ELEV. 1526.4
COMPUTE RATING CURVE FOR PIPES.

RATING CURVE FOR TWIN 15" CMP

REF. - KING'S HANDBOOK OF HYDRAULICS - 1954

$$Q = C a \sqrt{2gh} \quad d = 1.25' \quad L = 27'$$

$C = 0.52$ (TABLE 33 FOR CORR. METAL PIPE)

$a = 1.23 \text{ S.F.} \times 2 = 2.46 \text{ S.F.}$

$g = 32.2 \text{ FT. PER SEC}^2$

$h = \text{DEPTH ABOVE ORIFICE (W.S. - 1527.0)}$

W.S. ELEV.	H	CFS	
1526.4	-	0	
1528.8	1.8	14	Prior to overtopping
1530	3.0	18	overtopping condition
1532	5.0	23	" "
1534	7.0	27	" "
1536	9.0	31	" "
1538	11.0	34	" "

NOTE: RATING CURVE TO BE INPUT DIRECTLY

Outlet Works Data: 24" ϕ RCP, Normally closed.

$$\text{Discharge Capacity } Q = a \sqrt{\frac{2gH_T}{\Sigma K}} = 3.14 \sqrt{\frac{2gH_T}{2.16}}$$

$$\text{where } a = \text{cross-sectional pipe area} = \frac{\pi D^2}{4} = 3.14$$

$$H_T = \text{total head (feet)} = 1528.8 - 1518.5 + \frac{D}{2} = 9.3'$$

$$\Sigma K = K_e + K_v + \frac{29.1 n^2 L / r^4 s}{0.66} \quad (n=0.015; L=40; r=0.5')$$

$$\text{At normal pool Elev. } 1526.4 \quad H = 1526.4 - 1518.5 + \frac{D}{2} = 8.9' \quad Q = 3.14 \times \sqrt{\frac{64.4 \times 8.9}{2.16}} = 51.1$$

OUTLET WORKS DATA (CONTINUED)

$$\begin{aligned}
 \text{Min. dam crest elevation} & 1528.8 \\
 \text{1 pipe at outlet} & 1518.5 + 1.0 = 1519.5 \\
 \text{Total Head } H_T & = \frac{L^2}{2g} (K_{er} + \frac{29.10^4}{L^2} + h_V) = 9.3' \\
 Q = 3.14 \times \sqrt{\frac{64.4 \times 9.3}{2.16}} & = 52.3 \text{ cfs, say } 50 \text{ cfs}
 \end{aligned}$$

STORAGE DATA

ELEV. (FT.)	AREA (AC)	STORAGE (MG)	(AC. FT.)	DESCRIPTION
1487 (1)	0	0	0	RESERVOIR BOT.
1526.4	46	198*	604	NORMAL POOL
1528.8	51	236	720	TOP OF DAM
1540	67	451		CONTOUR

(1) ESTABLISH ELEV. @ 0 AREA

USE STORAGE PER BULLETIN 5 OF 198 MG @ ELEV. 1526.4

$$\Delta E = \frac{3S}{A} = \frac{(3)(604)}{46} = 39.5'$$

$$\text{ELEV. @ 0 AREA} = 1526.4 - 39.5' = 1486.9 \text{ (CALL 1487)}$$

S

* PENN-DER WATER RESOURCES BULLETIN No. 5

GEO-TECHNICAL SERVICES
Consulting Engineers & Geologists

JOB FOREST LAKE PA 0968

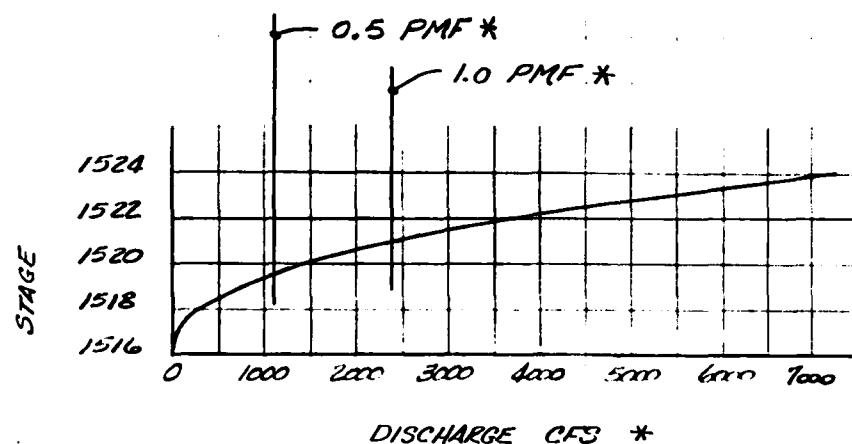
SHLT NO _____ OF _____
CALCULATED BY WEIL DATE 1/30/81
CHECKED BY _____ DATE _____
SCALE _____

CALCULATE TAILWATER @ DOWNSTR. FACE OF DAM

NORMAL DEPTH RATING CURVE AT DAM FACE

ITIV.	CFS
1517.0	46
1518.0	250
1519.0	731
1520.0	1476
1521.0	2461
1522.0	3692
1523.0	5292
1524.0	7243
1525.0	9527
1526.0	12100

NOTE: SEE SKETCH ON
SHEET D-10

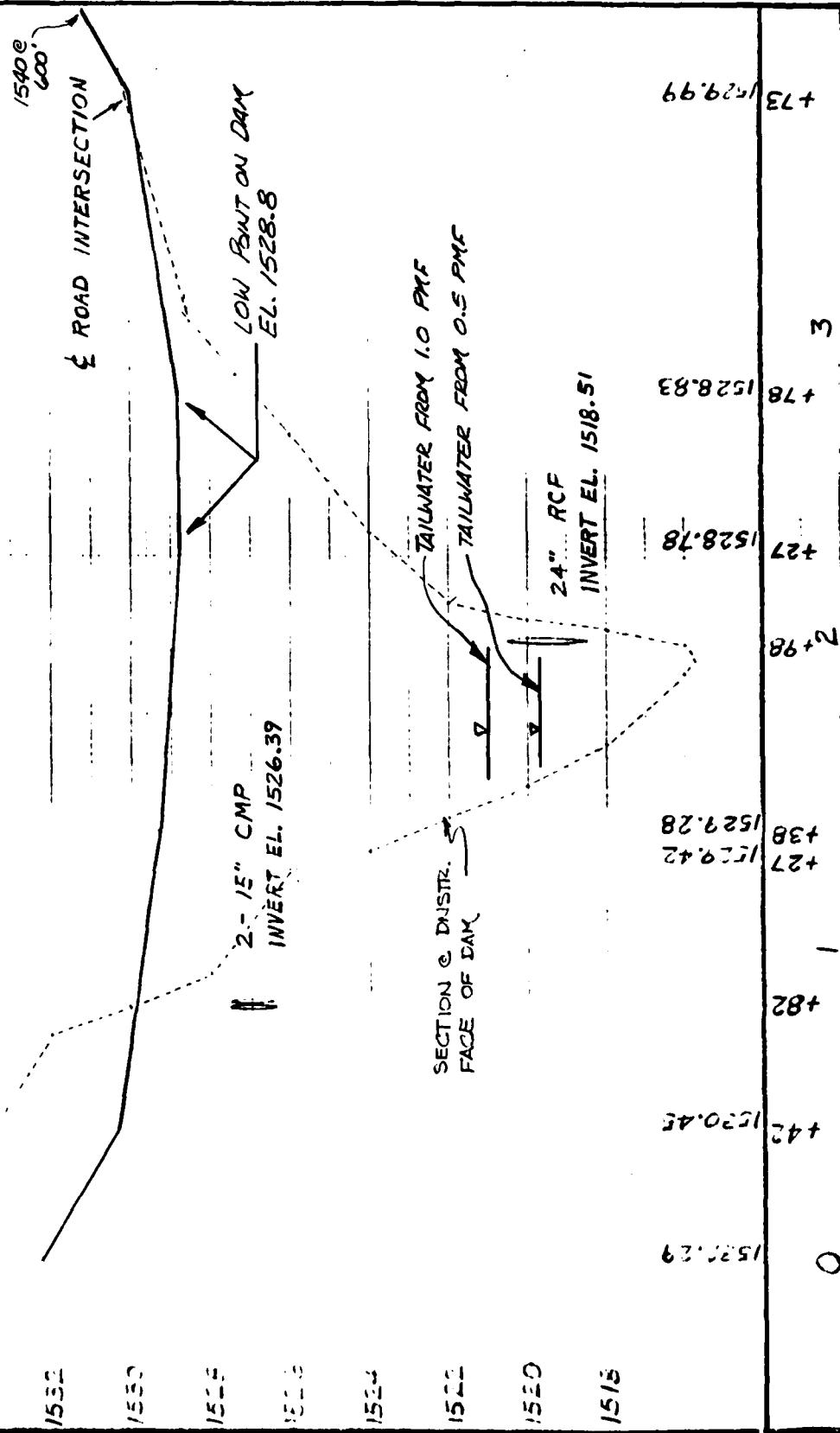


* THRU DAM

TAILWATER HAS NO EFFECT ON THE ANALYSIS (SEE SKETCH SHEET D-10).

RIGHT ABUTMENT

LEFT ABUTMENT



100 YEAR FLOOD DETERMINATION

Ref. : (1) C.O.E. Memo 4/22/81

: (2) HYDROLOGIC STUDY - TROPICAL STORM AGNES - COE DEC. 1975

: (3) BULLETIN NO. 13 - FLOODS IN PL. - USGS OCT. 1977

(4) Guidelines for Determining Flood Flow Frequency - WAC; Revised June 1977

METHOD A

COE REGIONAL REGRESSION (Ref. 2)

LAT. N $41^{\circ} 52' 48''$ LONG. W $75^{\circ} 51' 35''$

$$\text{Log}(Q_m) = C_m + 0.75 \text{ Log}(A) \quad Q_m = \text{Mean Annual Flow}$$

$$A = 0.84 \text{ mi}^2$$

$$C_m = 2.15'$$

$$\text{Log}(Q_m) = 2.15 + 0.75 \text{ Log}(A) = 2.09'$$

$$\text{Log}(Q_p) = \text{Log}(Q_m) + K_{pg} \cdot S$$

$$p = 100 \text{ yr}$$

$$g = 0.2$$

$$K_{pg} = 2.47 \quad (\text{From Ref. 1; } K_{pg} = 2.47226)$$

$$S = C_s - 0.05 \text{ Log}(A)$$

$$C_s = 0.35'$$

$$S = 0.35 - 0.05 \text{ Log}(0.84) = 0.35'$$

$$\text{Log}(Q_p) = 2.09 + 2.47(0.35) = 2.9545$$

$$\therefore Q_p = 900.5 \text{ cfs; } \text{Say } Q_{100} = 900 \text{ cfs}$$

METHOD B

BULL #13 (Ref. 3)

$$Q_T = C A^x - \text{Region 2}$$

$$T = 100$$

$$C = 564$$

$$x = 0.744$$

$$Q_T = 564(0.84)^{0.744} = 495 \text{ cfs}$$

Average Value of METHODS A & B

$$Q_{100} = \frac{Q_T + Q_p}{2} = 697.8 \text{ say } \underline{\underline{700 \text{ cfs}}}$$

100YR FLOOD

FLOOD HYDROGRAPH PACKAGE (FHP-1)
DAM SAFETY VERSION: JULY 1974
LAST MODIFICATION: 01 APR 01

FOREST LAKE NATIONAL PARK, ONTARIO, CANADA. (1974)

0-11

FLUO2 HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 01 APR '80

RUN DATE: 81/05/05.
TIME: 06:46:05.

NATIONAL DAM INSPECTION PROGRAM
FOREST LAKE DAM--PA0968 (COVERT CAPPING ANALYSIS)
FOREST LAKE TWP, SUSQUEHANNA CO, PA

	10	15	MIN	1DAY	1HR	IMIN	MEHR	IPLT	IPRI	NSIAN
JO5 SPECIFICATION								0	-4	0
JO6	0	0	0	0	0	0	0			
JO7	0	0	0	0	0	0	0			
JO8	0	0	0	0	0	0	0			
JO9	0	0	0	0	0	0	0			
JO10	0	0	0	0	0	0	0			
JO11	0	0	0	0	0	0	0			
JO12	0	0	0	0	0	0	0			
JO13	0	0	0	0	0	0	0			
JO14	0	0	0	0	0	0	0			
JO15	0	0	0	0	0	0	0			
JO16	0	0	0	0	0	0	0			
JO17	0	0	0	0	0	0	0			
JO18	0	0	0	0	0	0	0			
JO19	0	0	0	0	0	0	0			
JO20	0	0	0	0	0	0	0			
JO21	0	0	0	0	0	0	0			
JO22	0	0	0	0	0	0	0			
JO23	0	0	0	0	0	0	0			
JO24	0	0	0	0	0	0	0			
JO25	0	0	0	0	0	0	0			
JO26	0	0	0	0	0	0	0			
JO27	0	0	0	0	0	0	0			
JO28	0	0	0	0	0	0	0			
JO29	0	0	0	0	0	0	0			
JO30	0	0	0	0	0	0	0			
JO31	0	0	0	0	0	0	0			
JO32	0	0	0	0	0	0	0			
JO33	0	0	0	0	0	0	0			
JO34	0	0	0	0	0	0	0			
JO35	0	0	0	0	0	0	0			
JO36	0	0	0	0	0	0	0			
JO37	0	0	0	0	0	0	0			
JO38	0	0	0	0	0	0	0			
JO39	0	0	0	0	0	0	0			
JO40	0	0	0	0	0	0	0			
JO41	0	0	0	0	0	0	0			
JO42	0	0	0	0	0	0	0			
JO43	0	0	0	0	0	0	0			
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JO54	0	0	0	0	0	0	0			
JO55	0	0	0	0	0	0	0			
JO56	0	0	0	0	0	0	0			
JO57	0	0	0	0	0	0	0			
JO58	0	0	0	0	0	0	0			
JO59	0	0	0	0	0	0	0			
JO60	0	0	0	0	0	0	0			
JO61	0	0	0	0	0	0	0			
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JO67	0	0	0	0	0	0	0			
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JO82	0	0	0	0	0	0	0			
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JO166	0	0	0	0	0	0	0			
JO167	0	0	0	0	0	0	0			
JO168	0	0	0	0	0	0	0			
JO169	0	0	0	0	0	0	0	</		

UNIT HYDROGRAPH DATA

TF= 1.049 CPE= 0.62 MTA= 0

PERIODIC DATA

ST-TG= -1.0 0 QCSNE= -0.0 PTICK= 2.00

UNIT HYDROGRAPH DATA
ORDINATES, LAG= 1.049 MTA= 0.62 VOL= 1.00
16. 107. 167. 257. 236. 205. 197. 164. 134.
15. 54. 74. 52. 45. 37. 31. 26. 22.
14. 15. 12. 10. 8. 7. 6. 5. 4.
3. 2. 2. 2.

0.00A HRMN PERIOD RAIN EXCS LCSS
ST-OFF-PERIOD FLOW COMP Q P0.DA HP.MN PERIOD RAIN EXCS LOSS COMP Q
SUM 23.66 21.65 2.21 46249.
(606.)(550.)(56.)(1309.63)

HYDROGRAPH ROUTING

ROUTE THRU RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	I NAME	I STAGE	I AUTO
2	1	0	0	0	0	1	0	0
ROUTING DATA								
GLOSS	CLOSS	AVG	IRES	I NAME	I OPT	IPMP	LSTR	
0.0	0.000	0.00	0	1	0	0	0	
NSPS	NSTL	LAG	AMSKK	X	TSK	STORA	ISPRAT	
1	0	0	0.000	0.000	0.000	-1526.	-1	
STAGE	1526.49	1528.80	1530.00	1532.00	1534.00	1536.00	1538.00	
FLOW	0.00	14.00	18.00	22.00	27.00	31.00	34.00	
SURFACE AREA=	0.	46.	51.	67.				
CAPACITY=	0.	604.	720.	1379.				
ELEVATION=	1487.	1525.	1529.	1540.				
CREL	SPWID	COGW	EXPW	ELEV	COGL	CAREA	EXPL	
1526.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

D-13

DAM DATA

		TOPFL	COGD	FYPD	DAMWID
		152F.8	3.0	1.5	400.
CREST LENGTH	0.	105.	105.	365.	410.
AT OR BELOW ELEVATION	152E.6	152G.6	1530.6	1531.0	1532.0

PEAK OUTFLOW IS 11. AT TIME 47.51 HOURS

PEAK OUTFLOW IS 177. AT TIME 47.75 HOURS

PEAK OUTFLOW IS 453. AT TIME 47.75 HOURS

PEAK OUTFLOW IS 750. AT TIME 48.11 HOURS

PEAK OUTFLOW IS 1046. AT TIME 48.75 HOURS

PEAK OUTFLOW IS 1757. AT TIME 49.50 HOURS

PEAK OUTFLOW IS 2370. AT TIME 49.56 HOURS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7
			.10	.20	.30	.40	.50	.50	.75	1.00
HYDROGRAPH A1	1	.84	1	247.	493.	740.	967.	1233.	1850.	2466.
	(2.18)	(	(	(6.38)	(13.97)	(20.95)	(27.94)	(34.92)	(52.38)	(69.84)
ROUTED TO	2	.89	1	111.	177.	993.	792.	1096.	1757.	2370.
	(2.18)	(	(	(.31)	(5.03)	(13.95)	(22.62)	(31.02)	(49.75)	(67.12)

D-14

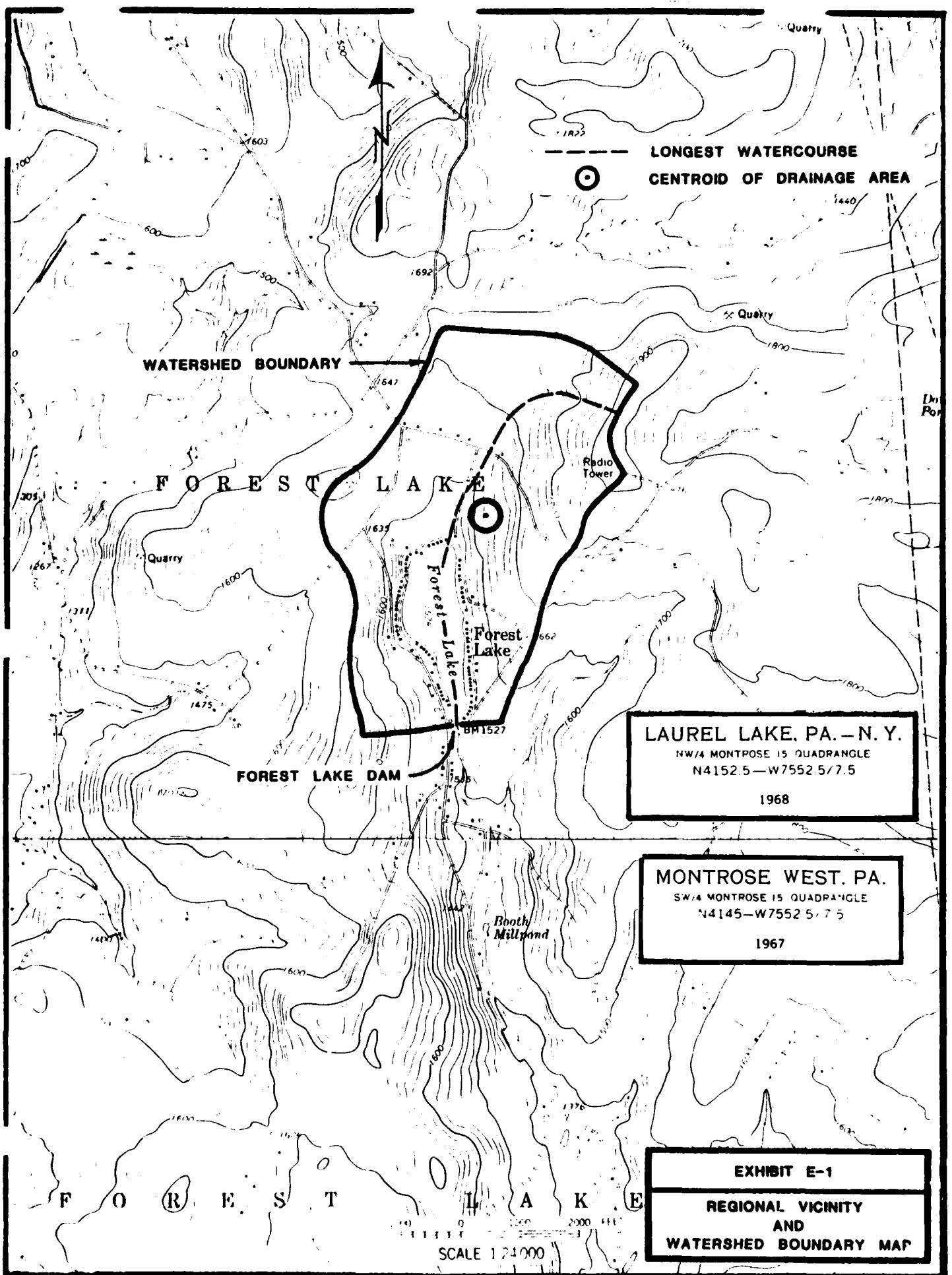
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	ELEVATION	STORAGE	OUTFLCS	INITIAL VALUE		SPILLWAY CREST		TOP OF DAM	
				1526.40	604.	1526.40	604.	1528.80	720.
RATIO OF PMF	MAXIMUM RESERVOIR W.S.FLEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFC	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS		
.10	1529.25	0.00	693.	11.	0.00	47.50	0.00		
.20	1529.45	.65	754.	177.	6.25	43.75	0.00		
.30	1529.87	1.07	776.	493.	7.25	42.75	0.00		
.40	1530.15	1.35	791.	799.	8.00	42.00	0.00		
.50	1530.36	1.56	802.	1096.	6.50	41.75	0.00		
.75	1530.76	1.96	823.	1757.	9.25	41.50	0.00		
1.00	1531.08	2.28	840.	2370.	9.75	41.50	0.00		

D-15

APPENDIX E

EXHIBITS



APPENDIX F

GEOLOGY

FOREST LAKE DAM

APPENDIX F

GEOLOGY

Forest Lake Dam and reservoir area are located within the Glaciated Allegheny Plateau Section of the Appalachian Plateaus Physiographic Province. Deposits of glacial drift of variable thickness cover the entire area. The drift was deposited by the Wisconsin Ice Sheet during the Pleistocene Period of geologic time.

The glacial drift is composed primarily of till which is a reddish-brown, unsorted, compact mixture of clay, silt, sand, gravel, and cobbles with occasional boulder sized pieces. The gravel, cobbles and boulders are sub-angular to rounded, consisting of sandstone and siltstone derived from the Catskill formation, the dominant rock formation of the area. The clay content and compact nature of the till makes it a relatively impermeable soil type.

Some deposits of glacial outwash are also found in the area. The outwash is composed of loose, poorly sorted to stratified deposits of silt, sand and gravel. The outwash deposits are generally very pervious.

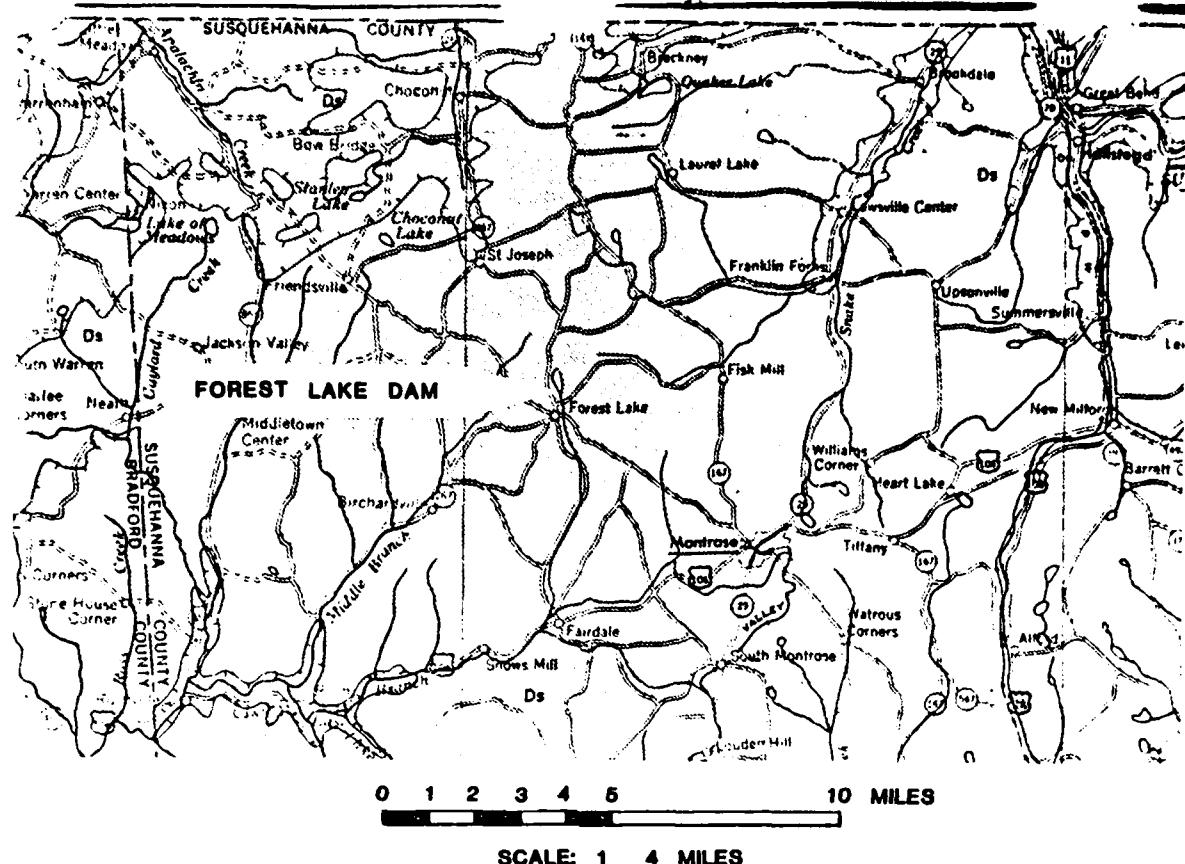
Other loose, pervious soils in the area are the recent deposits of alluvial silt, sand, and gravels with some clay. These soils are localized and limited to streambeds and flood plain area.

The bedrock underlying the entire dam and reservoir is the Catskill Formation of the Susquehanna Group. This group of formations is of the Upper Devonian age. The Catskill strata generally consists of well indurated red shale, siltstone and fine sandstone with some gray, green and brown shale and sandstone layers. Occasional conglomeratic layers are encountered. The red shales are the dominant lithology and the residual soils derived from this rock are usually high in clay and silt and contain numerous flaky and angular fragments and flat, slabby boulders. At the dam site, a large flat sandstone boulder is located on the left abutment near the spillway approach channel. The rock mass is boulder "float" that has migrated downslope from the hill to the east or it was deposited by the Wisconsin Ice Sheet. The dry masonry walls of the dam itself are constructed from similar flat, slabby one to two man sized boulders.

The regional structure of the bedrock in the area indicates the structure of the bedrock underlying the dam and reservoir area ranges from a broad flat fold to near-horizontal. The strike of the broad folds trend in a northeast-southwest direction.

Although depth to bedrock at the dam site is unknown, the steep earth slopes immediately downstream indicate at least 12 feet of overburden soil.

Ref.: *Ground Water of Northeastern Pennsylvania, Stanley W. Lohman, 1937; Bulletin W-4, Pennsylvania Geologic Survey*



LEGEND

DEVONIAN

UPPER

CENTRAL AND EASTERN PENNSYLVANIA



Oswayo Formation

Brownish and greenish gray, fine and medium grained sandstones with some shales and scattered calcareous lenses; includes red shales which become more numerous eastward. Relation to type Oswayo not proved.



Catskill Formation

Chiefly red to brownish shales and sandstones, includes gray and greenish sandstone tongues named Elk Mountain, Hemlock, Shohola, and Delaware River in the east.



Marine beds

Gray to olive brown shales, graywackes, and sandstones; contains "Chemung" beds and "Burke" beds including Burke, Rattler, Harrell, and Trimmers Rock; Tully Limestone at base.



Susquehanna Group

Barbed line is "Chemung-Catskill" contact of Second Pennsylvania Survey County reports; barbs on "Chemung" side of line.

NOTE:

GEOLOGIC MAP AND LEGEND
OBTAINED FROM GEOLOGIC MAP
OF PENNSYLVANIA BY PA.
TOPOGRAPHIC AND GEOLOGIC
SURVEY, DATED 1960

PHASE 1 INSPECTION REPORT NATIONAL DAM INSPECTION PROGRAM

FOREST LAKE DAM GEOLOGIC MAP

GEO - Technical Services, Inc.
HARRISBURG, PA

FEBRUARY 1981

EXHIBIT F

